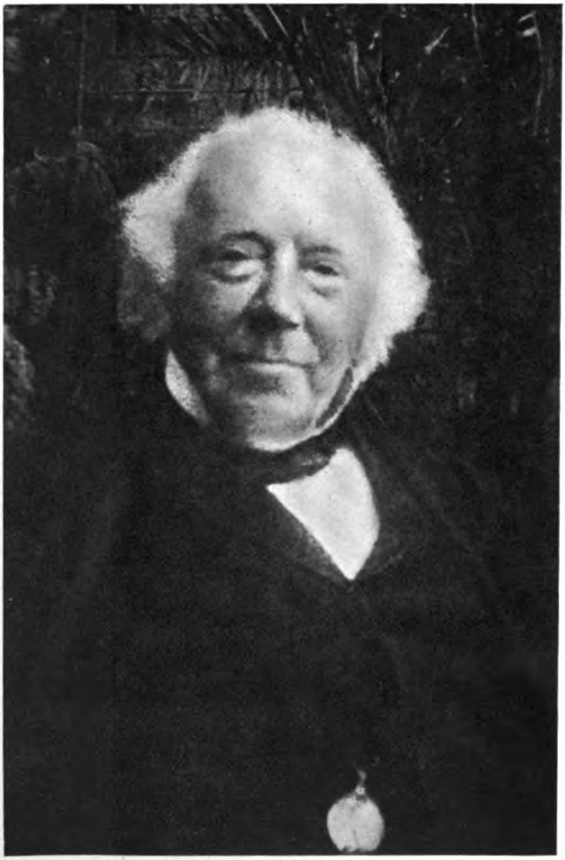

SIR FREDERICK BRAMWELL, BART.

PAST-PRESIDENT INST. C.E.

DIED 30 NOVEMBER, 1903.

MINUTES OF PROCEEDINGS

OF

THE INSTITUTION

OF

CIVIL ENGINEERS;

WITH OTHER

SELECTED AND ABSTRACTED PAPERS.

VOL. CLVI.

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CORRIGENDA.

Vol. cl. p. 300, opposite Reference Number 108, insert in Remarks column "Jacket-drainage returned direct to boiler."

" p. 310, opposite Reference Number 108, insert in Remarks column "Jacket-drainage passed into the hot-well."

The Institution of Civil Engineers.

The subject-index to the Library Catalogue, 1895, being now in type, the Council have ordered that members should have the opportunity to purchase the "Author" and "Subject" Catalogues (the former comprising three 8vo. volumes, and the latter two volumes). The price is fixed at 4s. per volume to cover the cost of paper, printing, and binding in the official cloth covers.

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THE
INSTITUTION
OF
CIVIL ENGINEERS.

SESSION 1903-1904.—PART II.

SECT. I.—MINUTES OF PROCEEDINGS.

15 December, 1903.

Sir WILLIAM H. WHITE, K.C.B., D.Sc., LL.D., F.R.S., President, in the Chair.

(*Paper No. 3453.*)

"Deposits in Pipes and other Channels Conveying Potable Water."

By Professor JAMES CAMPBELL BROWN, D.Sc.

THE various deposits which lessen the carrying-capacity of water-pipes, culverts and tunnels range themselves naturally under three classes:—

I. Incrustations on unprotected or imperfectly-protected iron pipes.

II. Deposits on the inner surface alike of iron pipes, whether protected or unprotected, and of culverts, rock tunnels and other channels; the deposits depending in their nature on the composition of the water, and occurring over the whole of the surface covered by the water.

III. Accumulations of débris in inverts, on hollows and irregularities in the water-channels, and in the *culs-de-sac*.

I. INCRUSTATIONS ON UNPROTECTED IRON PIPES.

Incrustations are formed by the corrosion of iron pipes, valves and other ironwork, where the inner surfaces are not protected by a layer of pitch, or where the protecting layer is imperfect.

These incrustations begin as minute projections dotted all over the pipes in very varied numbers—sometimes in rows, sometimes in an irregular manner. In form they resemble the limpets to be found on a rocky sea-coast; they are more or less conical in shape, often with a steep and a more sloping side, and grow by addition of concentric layers. The steep side faces the current. They increase

in size and in number, until in badly-protected pipes they ultimat become confluent, and form a coating of considerable thickn This kind of incrustation may be nearly uniform from the c mencement, in which case nodules are not then seen; but the nat of the incrustation is the same. A pipe of small calibre is so times completely blocked by the incrustation. In large pipes thickness of the deposit does not appear to be unlimited. In pipes, when the incrustation is about 1 inch to 1½ inch thick it d not seem to increase, possibly owing to the density of the incrusta acting as a protection; but if the incrustation is removed, or if conical tips of the "limpets" are broken off, it begins to g again with renewed activity. For this reason it is unadvis to use a scraper for removing the nodules or incrustations. obstruction is only temporarily removed, and if the use of scraper is continued, the life of the pipe is greatly reduced the more rapid corrosion of the iron.

Fig. 1, Plate 1, shows a broken iron pipe with incrustati Fig. 2 shows limpet-shaped incrustations beginning to bec confluent. Fig. 3 is a section of one of the limpets. The cer portion is black when fresh, and soft. It often contains a l sulphide of iron as well as oxide; it becomes red on expo to air; the middle layers are often orange-red ferric oxide, sometimes contain iron-organisms of the well-known rosary (Figs. 4 and 5), which a high magnification resolves into a do ribbon-shaped spiral twisted closely upon itself. The limpet-sh cones vary in consistence; when well developed they are outside and softer within. The outer concentric layers denser, sometimes quite hard; they are composed of ferric o but include hard black layers of magnetic oxide of iro which dead organisms can occasionally be found. The int is softer; generally black when fresh, but becoming red o posure. Sometimes there are orange layers between the interior and the hard outer crust.

It has been suggested that the incrustations are produc started by iron-organisms; and again, that they are the res acids in the water acting on the iron of the pipes. Observati a variety of examples in Great Britain and Ireland and in countries disproves each of these conjectures. Although orga are found in some incrustations, and may modify their compos yet incrustations are often free from every trace of life. They equally in waters which contain no iron-organisms (Nos. 1 an Table III. of the Appendix), and in waters from which all orga have been removed (Nos. 1, 4, 5, and 12 after filtration, Table

and although acid waters and waters containing manganous salts no doubt hasten the corrosion of iron, nevertheless the Author finds incrustations to be formed not only by acid waters (Nos. 1, 2, 3, 12, 13 and 17), but by water which is neutral (No. 7), and even alkaline (Nos. 5, 9, 14 and 15). No incrustations are formed, however, when the iron is effectively protected by any means from contact with the water.

The iron of the incrustation is in all cases derived from the iron of the pipe. The incrustations occur in water containing no iron in solution, such as Nos. 7, 9, 14, 15; the iron of the pipe is always dissolved out to a considerable extent where they occur; and the pipe is soft, black, and spongy beneath the limpets. In a piece of incrusted pipe which had been subjected to the action of an alkaline water flowing through it for upwards of 40 years, the iron when fresh could be cut by a knife half-way through from the inner surface. The action is therefore not due to acidity in the water.

Many incrustations contain no trace of organisms; but so far as the Author's observations go, when present, organisms appear to modify the composition of the limpet. The rosary-shaped form (Figs. 4 and 5, Plate 1) does not belong to one organism only, but is assumed by several different organisms at a certain stage of growth. Wherever it occurs the Author has always found the usually black iron compound converted into red ferric oxide; he has frequently found remains of dead organisms forming a layer close to the hard magnetic-oxide layers near the exterior. These are short, and have not the rosary form; but they may be the same organism. The occurrence of sulphide in the interior may be due to reduction of sulphates in the water, either by anaerobic organisms, which the Author has never been able to detect, or by the chemical action of metallic iron. In the laboratory, weak solutions of sulphates have been reduced alike by cultivations of the soft black internal portions of limpets, and by filings of metallic iron. There is not enough sulphur in the metal of any pipe which the Author has analyzed to account for the sulphur sometimes found. The compositions of five specimens of incrustations are given in Table I. of the Appendix.

No chemical treatment, not even the neutralization of acid waters by slight excess of lime or of caustic soda, prevents the corrosion and incrustation of iron pipes. The only treatment quite effective is the coating of the iron pipe by a smooth and perfect layer of pitch. For this purpose the pitch must be as free as possible from such hydrocarbons as either vola-

B 2

tilize or dissolve by long exposure to flowing water. It should laid on to the hot clean iron; and as the first coat is liable to h pin-holes or air-holes, which become centres of "limpets," pipes should always receive a second coat. The coating of pi must be continuous and complete; it should be smooth and h but not so hard as to be brittle. It is difficult to secure a] fect coating, and not easy to find a supply of suitable pi Although the process is essentially the same as that employed Dr. Angus Smith, the material and the process which go by name in commerce are not very satisfactory. The first coat n be cooled before the second is applied, and the second "dip" n be neither so hot nor so prolonged as to melt the first coat. repair the coating on a laid pipe-line, it is possible to lay on pitch with a brush, but it is very difficult to make the l sufficiently perfect in this way.

II. Deposits and Growths depending on the Composition of Water.

Calcium Carbonate.—The first deposit depending on pecu composition of the water is the translucent and semi-crystall scale of calcium carbonate, formed by the escape of carbonic from water containing bicarbonate of lime. This kind of de has been so long and so well known that there is no necessit do more than mention it. A good example of it is found in ancient Roman aqueduct of the Pont du Gard, in France, w a lining about 1 foot in thickness was formed in the cours centuries, and reduced the carrying-capacity by something like half before the aqueduct was broken. Other examples are fam in the pipes, large and small, which convey many hard wa Boiling the water or agitating it hastens the deposition. best treatment is the well-known process of Dr. Clark, w consists in adding an equivalent quantity of milk of lime running off the clear water after settlement.

The organisms growing in these calcareous waters are ch Confervae, Desmids, and other plants in which green predomina and these sometimes form a slimy layer on the inner surfac cold pipes.

Black Slime.—A second kind of deposit is a black, slimy li formed wherever the flowing water is in contact with the sid ~es, culverts or tunnels. This deposit contains a great deal of i he iron is not derived from pipes, because the deposit occu

protected as well as on unprotected pipes, and on stonework, woodwork, brick and rock surfaces, where the water has never been in contact with pipes, nor with ironwork of any kind. The deposit lessens the flow of water, not only by diminishing the sectional area of the pipes, but also by greatly decreasing the velocity of the water. This slimy layer has been called peaty, but the Author has never been able to find any particle of peat in it.

The slime has been attributed to the deposition of matters suspended in the water: but matter mechanically carried down is deposited chiefly at the invert of a pipe or culvert, and accumulates in siphons and in other depressions in the water-channels when the current is not strong enough to carry it forward; whereas the slime here referred to forms as thick a layer at the top and on the sides of pitch-coated pipes as at the invert. The composition is essentially the same all round the pipe, except that more siliceous and rock or clay particles are entangled in it at the invert (see Analyses of slimes Nos. 1 and 2, in Table II.). Further, the composition is similar at the beginning and at the end of a pipe many miles long, after it has been conveying water for years (see Analysis No. 3). It has also been imagined that the particles adhere all round the pipe by their consistency and stickiness, and vortex action has been invoked to account for their equal distribution: but particles breaking loose do not, in fact, adhere to the sides of pipes; they are either carried along or fall to the bottom; while vortex action, if any, bears them along, rather than causes them to adhere to the top of the pipe.

Chemical Composition of Slime.—The chemical composition is shown by the analyses appended (Table II.). Examination of a large number of these deposits from several sources has shown that the dried slime contains a small quantity of vegetable carbon compounds, but no trace of peat; and that it consists mainly of organic matter containing much ferric hydrate together with manganic and manganous oxides, giving a black colour to the whole; while entangled in the mass are minute particles of rock, diatoms, and remains of various organisms, with a small quantity of precipitated iron oxides.

That the iron comes from the water, and not from the iron of the pipes, is proved by the following facts:—

1. Similar slime is found in rock tunnels before the water has been in contact with iron.

2. The slime is found as plentifully on the sides of pipes completely protected by a coating of pitch as on uncoated iron.

3. The water always contains iron when slime is found (see

Analyses of waters Nos. 2, 3, 12, 13, etc.), while water from simi gathering-grounds, but containing little or no iron, does not p duce this kind of slime (Analyses of waters Nos. 5, 7, 9, 15, etc

4. In a very long length of pipe, iron was found to predomin in the first few miles, while the quantity of iron decreased, a manganese increased, in the last few miles. (Compare Analysis slime No. 3 with Nos. 1 and 2.) The water was saturated w oxygen throughout the length of the main.

5. The amount of iron in a certain water was determined different points on the same pipe-line on the same day, with following result:—

	Parts per 100,00
Water at starting contained total iron	0·045
After 15 miles in iron pipes imperfectly protected	0·04
After filtration	0·024

During the winter of 1899, when examining specimens of sli the Author observed—besides diatoms, broken crustaceans other organisms frequently found in water from catchment-area a large number of the hyphae of what are known as iron-bacte These consist of threads or tubes which are at first pale, t coloured yellow; as they grow older they acquire a gela ous sheath in which ferric hydrate is deposited; this thick until it entirely obscures the original structure and appare kills the oldest end of the organism, which breaks up int tangled mass of gelatinous ferruginous organic matter, in wl the structure is lost (Figs. 6, 9, 13, Plate 1). The Au observed that while the dead jelly adhered to the pipes, the were still growing, Fig. 7.

The relation of the remains of the original carbon compoun the ferric deposit in the mass of the dead slime is shown observing a certain portion of slime, fixed under the microsc and then slowly dissolving away the iron and manganese oxalic acid, taking care to prevent as far as possible a chang the relative position of the parts. The gas evolved by the ac of manganese dioxide on oxalic acid always spreads out the lig parts of the structure in spite of every care (compare Figs. 9 13 with Figs. 10 and 14). The organic residue is paler tha the Figure. In order to render it more distinct for a photogr it is stained with methylene blue (Figs. 11, 12 and 14). T pale residues, after treatment by oxalic acid, are proved to be broken-down remains of the carbon compounds of the organism

That the black slime is not due to peat is shown by the follow facts:—

1. By analysis the dried substance yields:—

	5 Months Old. Per cent.	Very Old. Per cent.
Carbon	41·77	29·43
Hydrogen	8·77	8·64
Nitrogen	4·68	4·21
Oxygen	44·78	57·72
	100·00	100·00

2. No trace of peat has been found in any deposit from these waters; and in other waters in which particles of peat have been found at the consumer's tap, no appreciable quantity of slime is found in the pipes. Peat is not decolorized by oxalic acid, while the dark slime is. Fig. 17 shows decayed particles of peat after treatment with oxalic acid, but not stained by methylene blue.

3. Although decomposed peat does not give all the reactions of cellulose, the vegetable matter being somewhat altered by decomposition, yet it gives different reactions from the slime residues and has a different composition, the slime residue nearly resembling the composition of fresh organic jelly.

	Old Peat Residues Treated with Oxalic and Hydrochloric Acids. Per cent.
Carbon	55·47
Hydrogen	5·79
Nitrogen	3·15
Oxygen	35·59
	100·00
Oxide of iron removed by hydrochloric acid	5·2
Other mineral matters in ash	5·6
	110·8

4. The slime does not accumulate for several years, whereas peat would begin to be deposited in the first year.

5. The organic filaments are found in the covered-up mass where no peat, even if present in the water, could reach, on account of the ferruginous sheath. Everything except rock particles has come from solution in the flowing water.

6. An experiment was made by taking from a rock tunnel water which came in contact with no ironwork, carefully straining out all minute particles of peat or other solid matter, including growing organisms, through an exceedingly fine sieve, and then allowing the water to flow into pipes well protected by a layer of pitch. After 5 months a coating of black slime was

formed all round the interior of the pipes, which had composition shown in the analysis of slime No. 4 (p. 15).

The formation of this coating was watched by means of microscope. First there appears a living and growing j adhering to the surface of the pipe; dots, and, some months la spirilla-shaped organisms, appear in this jelly. Iron begins t deposited not on but in the jelly; and ultimately there are l threads in the jelly, which acquire a sheath. The sheath thick by deposition of iron oxide, and the living thread elongates m and more, the sheath following up the thread. A tangled n results: the older portions become more tangled and dense: all the time particles are mechanically entangled. Finally organism dies at the older end and breaks down, losing its fo and becoming a gelatinous, flocculent mass of dark ochreous depo with the younger sheaths and living threads growing out of like Fig. 7. Treated with oxalic acid at this stage, the metals dissolved, and disclose faintly the broken down and shape carbon compound of the disintegrated threads, some of the shea occasionally remaining visible. Figs. 18, 19 and 20 show sta in the first year's growth on the surface of coated pipes.

Theories of the Growth, etc., of Iron-organisms.—Organisms all to those here described caused a great deal of trouble in 1879 the Berlin waterworks, in 1889 at Rotterdam, and at various tin in many other waterworks in Germany and Italy. Ea observers saw that there are various organisms peculiar to wat containing iron, and it was thought that they could not l without iron. Cohn[1] thought iron oxide had some relation to vegetable activity of the cell. Zopf[2] thought Cohn was wro Writing in 1882–5, Zopf considered the collection of the i oxide to be a mere mechanical process, because, according to observations, empty cells become coloured if placed in ferrugin waters by the iron passing into them. There is a fallacy Zopf's reasoning, because in these and some similar organisms t iron oxide gets into the full and active cell.

Next, a student named Winogradsky[3] wrote a graduation ess affirming, somewhat rashly, his opinion that these organisms u ferrous bicarbonate as food, whose decomposition and oxidati sustains vital energy, and plays a part in life similar to th

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[1] F. Cohn, Beiträge zur Biologie der Pflanzen, Pt. ii. p. 127. Breslau, 187

[2] W. Zopf, "Die Spaltpilze." 3rd ed. In A. Schenk's "Handbuch Botanik," Vol. iii. Pt. i. Breslau, 1884.

[3] S. Winogradsky, "Ueber Eisenbacterien," *Botanische Zeitung*, 1888, p. 26

which sulphuretted hydrogen plays in the sulphur-bacteria. This certainly cannot be true; for in some of the waters to which the Author has paid most attention, there was no ferrous bicarbonate at all, in fact, no bicarbonate of any kind; and in others there was hardly a trace of carbonate or bicarbonate. The Author had difficulty in getting these organisms to remain alive in very dilute ferrous bicarbonate without hay-infusion; but he succeeded in cultivating them in water containing simply an infusion of hay, when they of course excreted no iron; while on addition of ferric salts to the hay-infusion they developed ferruginous tangle as they did in a stream (Figs. 15 and 16). Fig. 15 shows organisms from slime developed in the laboratory in an infusion of hay with a little ferric salt added. Fig. 16 shows the same organisms developed in a Welsh stream.

Molisch[1] of Graz, in 1892, arrived at the conclusion that the colour is not exclusively due to iron, and that Cohn's and Zopf's organisms developed well without the smallest quantity of iron being present. He disputes the opinion that the organisms take up ferrous iron. He points out that it should be possible to recognize iron in the cell, but he says it never is; and he thinks the jelly surrounding the sheath acts chiefly as a filter to keep back, store, and, if necessary, oxidise the iron without letting it pass into the cell. The Author's observations satisfy him that in this last respect Molisch was not correct, although his criticism of Winogradsky's views is undoubtedly correct, and it is certain that the oxidation of ferrous iron does not supply the vital energy.

The best account and classification of these organisms were given by Migula[2] of Carlsruhe. He names them *Chlamydothrix*.

According to the Author's observations, therefore, this kind of slimy deposit arises in the following way:—The germs and young forms of *Chlamydothrix* come down with the water, and can be found in it by filtration or centrifugal separation. They attach themselves to, and grow on, the inner surface of the pipes and channels. It is known to botanists that these organisms grow attached to something, rather than freely floating in water. First, there is a jelly with specks in it. These specks enlarge and become spiral, then long and twisted, and then become threads (Figs. 18, 19, 20, Plate 1) having a gelatinous sheath. Iron oxide is deposited in the gelatinous sheaths, which continue to thicken.

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[1] H. Molisch, "Die Pflanze in ihren Beziehungen zum Eisen," p. 63 Jena, 1892.

[2] W. Migula, "System der Bakterien," vol. i. Jena, 1897.

The older part becomes choked and intertwined, dries, disintegrates; while the thread-like organism pushes out the free end, and the thickening sheath follows it up (Fig. While these tangled filaments are growing, the solid parti in the water and broken-off floating organisms are caught retained by the gelatinous threads. There may possibly some chemical separation of the oxide of iron; if so, this beco entangled also; but the oxide of iron comes chiefly from the v known deposition in the jelly of the organisms; and in the wa which the Author has studied the iron is not set free from solut except by the destruction of the carbon compounds which hol in solution. The consumption of the carbon compounds is ca by the organisms living upon them. The oxide and dioxid manganese, which occur in black patches and particles in slime, have a different origin. Water containing traces of n ganese salts forms by oxidation small concretions of dioxid mixed oxides. This has been proved by examination of nat waters,[1] and by experiment in the laboratory. Particles of ox of manganese thus chemically deposited are entangled also, blacken the slime. If they and other solid particles were entangled in the slime, they would be found at the bottom of culvert, and not equally at the top and sides.

Conditions of the Growth of Slime in Natural Waters.—A compar of natural waters will be of service in considering what ditions are favourable to the growth of slime, and what condit are unfavourable.

Referring to the analyses of water (Appendix, Table No. I No. 12 is water collected from a surface having several peat-l and much upland pasture, and hardly any cultivation, on a of Silurian rock. There are several ferruginous springs on gathering-ground. The water is always acid, although it cont neither carbonic acid nor carbonates, and no free mineral a It contains both iron and manganese; and only about 4 part total solids per 100,000, with a relatively large proportio carbon compounds. This water yields much slime.

No. 2 is from a very similar gathering-ground. It cont $5\frac{1}{2}$ parts of dissolved matter per 100,000, including organic a no ferrous iron, but 0·016 part ferric iron, and a trace of n ganese. The hardness is 2·2, of which 0·52 is removed boiling, and 1·69 is permanent. It is comparatively very s

[1] H. S. Pattinson, Trans. Newcastle-on-Tyne Chemical Society, vol. iv., p. 219.

but contains few carbonates and no free mineral acids, yet much of the acidity remains on boiling. This water yields much slime, like Fig. 8. (See Analysis of slime No. 7.)

The gathering-ground of water No. 3 is similar, but has more cultivation on it. The water has 5·6 parts of dissolved matter, 0·6 organic carbon, 0·1 nitrogen. It is very soft, contains a quantity of iron and a trace of manganese. The acidity is equivalent to 0·22 lime, and is not removed by boiling. This water yields slime with long strings of iron-organisms.

No. 13 is from a similar gathering-ground on Old Red Sandstone. It contained iron-organisms as well as other organisms, and yielded both slime and incrustations. All the above waters yielded slime full of the hyphae and remains of iron-organisms.

No. 14 water is from a similar gathering-ground to No. 13, on Upper Silurian rock. It contains 16·06 parts of dissolved matter per 100,000, only a trace of iron, and no manganese; but it contains large quantities of carbonates, and has an alkaline reaction. This water contained no iron-bacteria and formed no slime; but it did form an incrustation by the oxidation of iron pipes.

No. 1 is from an upland gathering-ground with pasture and moss-land very little cultivated. It is slightly acid to test-paper. Although a few iron-organisms have been found in it, there is no growth of slime in the pipes; but there is the usual incrustation on unprotected pipes.

No. 9 water is from a surface having a large area of peat moss, upland pasture, barren hills, and some cultivated land on gneiss and schist. It is almost neutral, but slightly alkaline. It forms no slime; the growth in the water-channels is represented by Fig. 21, Plate 1, and consists of freshwater sponges, with a few fungi and diatoms and other organisms. Incrustations on pipes carrying this water have the usual composition, as shown in Table I., Nos. 2, 3, and 4.

No. 7 water is from upland pasture and hill surface on crystalline schists, slate and grits, with peat and scarcely any cultivated land. It is nearly neutral, and if sometimes slightly acid it becomes alkaline on boiling, through escape of carbonic acid gas. It contains some peat, 0·21 part of organic carbon per 100,000, only a minute trace of iron, and no manganese. It forms incrustation on iron pipes, but no growth of slime.

No. 4 is from a hill gathering-ground with much peat, on primitive rocks, and is filtered. It contains 6·7 parts of dissolved matters per 100,000, including much organic matter, but hardly iron. It has an acid reaction, but this disappears on boiling,

is therefore due to carbonic acid: after boiling, the water is just perceptibly alkaline. This water forms no slime, but forms incrustations on iron.

No. 5 is from low hills of primitive rock and some limestone. It contains in solution 9·9 parts of solids per 100,000, including a large proportion of organic matter and very little iron. The reaction is alkaline. The water forms no slime and no iron-organisms; the organisms found in it are chiefly of a green vegetable character, such as Desmids, etc.

No. 15 is from Lake Ontario. It contains 18·48 parts per 100,000 of total solids in solution and only 0·006 of iron. It is alkaline, forms no slime, and contains no iron-organisms. It does form incrustations on iron.

Two questions may now be considered, namely, what is the cause of the growth of ferruginous slime? and how can it be prevented?

Cause.—It is evident that acidity other than carbonic acid always characterizes water which produces this ferruginous slime; alkaline water never grows any, so far as the Author has seen, nor does neutral water. Bicarbonates, which imply lime and magnesia, seem to be opposed rather than favourable to the growth: organic matter alone does not produce it: and a trace of iron in neutral and alkaline water is quite consistent with absence of slime. But an appreciable quantity of iron in solution, in combination with organic matter of an acid character, is an invariable accompaniment of the slime. Traces of manganese are often present also, and produce a deposit of particles of manganese dioxide which darken the slime; but these are not essential. This is a purely chemical and mechanical phenomenon, and appears in water which exhibits no growth of slime—for example, the water analyzed by Mr. H. S. Pattinson in 1879, which has already been referred to.

It is hazardous to conjecture a solution of the iron phenomena, when so many observers have propounded, one after another, quite incorrect theories; but many circumstances point to some such explanation as the following:—The slime-organisms live on the carbon compounds in a soluble organic compound of iron, which penetrates into their substance, even into the inner tube. Whether the iron performs any function or not, the carbon compounds support life, and the iron oxide is necessarily deposited throughout the whole mass of living matter, but chiefly in the active parts. It thickens the sheath, until the organism, throwing out fresh tips at one end, dies at the other end and breaks up into the gelatinous matter which is seen

when iron is removed from masses of slime by oxalic acid (Figs. 10, 11, 12, 14).

The deposition of manganese dioxide[1] is, the Author is satisfied, the result of oxidation by the oxygen dissolved in the water. Oxygen dissolves in water very quickly to the extent of about 6 volumes per thousand; and water was found to be saturated with oxygen after passing through 19 miles of pipe in which slime was growing. During its passage it had opportunities of replenishing its oxygen. On the other hand, the dissolved iron was reduced from 0·028 to 0·02 on passing through the same 19 miles.

Prevention.—Two modes of attack are open for the purpose of checking the growth of ferruginous slime on the inner surface of water-channels, namely, either by introducing conditions fatal to the growth of the organism, or by removing its food. Neutralization of the acidity of the water, by lime and by soda, has been tried experimentally. A modification of the Clark softening-process was employed, with the result that no iron-organism grew in the completely neutralized or slightly alkaline water, although side by side with the treated water, other pipes carrying untreated water developed jelly and well-marked iron-organisms in the same period of time.

The action of an alkali, or alkaline earth, does not precipitate the iron oxide; on the contrary, alkali causes the solution of the organic compound of iron by distilled water. Straining through the finest gauze does not prevent the growth of slime in the water afterwards, although it greatly delays it, and lessens the quantity in a given time. It is, however, only a question of time, and, ultimately, the slime grows again as before.

The result appears, so far, to be different with filtration, if thorough. In more than one water, within the Author's knowledge, filtration has prevented the appearance of the growth of slime beyond the filter-bed, although it does not diminish the growth of incrustations. Efficient filtration removes the organic matter, and so removes much of the iron held in combination with the organic acid; and the Author has never seen slime grow to any extent in water after good filtration. But there is evidence of a growth of organic jelly, containing oxide of iron, forming a thin film in pipes beyond efficient filter-beds; and it is conceivable that this may, after the lapse of sufficient time, grow in the same manner as before filtration, though at a slower rate.

[1] The Author has seen a mass deposit of manganese dioxide on brickwork in a culvert accumulated in many years from water containing only a minute quantity of manganese salts.

The temporary removal of slimy growths can be effected by a convenient form of brush, devised by Mr. G. F. Deacon, M. Inst. C.E. This must be so soft as not to detach or break the incrustations, if any, beneath the slime. But it is far better to prevent the growth of slime, in waters favourable to it.

III. Loose Deposits.

These consist of mud, particles of rock and clay, remains of dead organisms; with which, in the case of ferruginous waters, are mixed portions of the slime broken off from the growth in the pipes by the flow of the water. Such deposits lie in the hollows of the pipe-line, and impede the flow at the lower parts and on the upward inclines. They are not confined to waters growing the ferruginous slime. These deposits can be removed by rapid sluicing or by brushing, and need no further mention here.

The Author has to thank Mr. James Mansergh, Past-Presiden' Inst. C.E., Mr. G. F. Deacon, Mr. Joseph Parry, Mr. W. M. Gale Mr. W. Dyack, MM. Inst. C.E., and many other engineers, for in formation, samples and assistance in the course of these investiga tions; Mr. R. R. Tatlock of Glasgow, Mr. T. Jameson of Aberdeen and other chemists, for analyses and information; and Professo. R. J. Harvey Gibson, of Liverpool, for valuable advice.

The Paper is accompanied by twenty-one blocks, from whic Plate 1 has been prepared, and by t[illegible]llowing Appendix.

[Appendix.

APPENDIX.

TABLE I.—ANALYSES OF INCRUSTATIONS.

—	1 Young Incrustations produced in 5 months on uncoated iron pipes by No. 12 Water containing no iron organisms, its acidity neutralized by lime.	2 Old Incrustations on iron pipes from No. 9 Water, which contains no iron organisms, and has an alkaline reaction.	3 Conical Incrustations containing a hard magnetic layer, but no soft orange layer, and no sulphide. No. 9 Water, alkaline reaction.	4 Old Incrustations containing black sulphide in centre and an orange layer, with rosary-shaped organisms. No. 9 Water, alkaline reaction.	5 Incrustation removed from iron pipes by a scraper.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Moisture . . .	2·62	9·4	5·61	4·88	2·74
Loss on ignition .	24·19	20·5	21·38	18·34	10·96
Ferric oxide . . .	57·95	61·87	58·48	59·46	76·2
Ferrous oxide . .	9·17	4·15	8·78	14·4	
Lime	2·06	0·56	0·23	..	0·075
Magnesia . . .	trace	none	..	0·1	trace.
SO_3 combined . .	1·43	0·80	0·32	0·2	0·28
Sulphur	trace	..	0·34	0·05	
Insoluble in hydrochloric acid . .	2·58	1·79	4·81	1·55	7·2
Undetermined . .	..	0·93	0·05	1·02	2·545
	100·00	100·00	100·00	100·00	100·000

TABLE II.—ANALYSES OF SLIME.

—	1 Sides of pipe.	2 Bottom of same pipe.	3 Same pipe 11 miles farther on.	4 Slime on side of protected pipe (after 5 months' flow direct from rock tunnel).	Slime several Years old. 5 Slime. 19 April, 1900.	6 Slime; 14 miles farther on, March 1901.	7 Mature Slime from No. 2 Water in protected pipes.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Ferric oxide . .	42·23	39·72	25·11	39·39	28·14	33·19	33·73
Ferrous oxide . .	none	none	none	trace	none	none	
Manganous oxide .	5·98	6·65	19·91	17·38	17·17	11·82	16·58
Manganic peroxide	9·58	10·34	17·77	1·30	19·84	8·63	26·83
Lime	1·67	2·80	1·24	1·57	0·70	2·55	2·70
Magnesia . . .	13·74	9·83	1·45	1·64	1·69	0·21	1·15
Sulphates . . .	trace	trace	trace				
Sulphides . . .	none	none	none				
Loss on ignition, combined water, animal and vegetable matter[1] .	26·80	30·66	34·52	33·63	27·67	42·12	19·01
Undetermined . .	..	..	..	5·09	4·79	1·48	
	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Sand and insoluble matter . . .	24·66	37·18	36·7	43·89	48·04	13·27	
Including carbon	8·17	..	9·98	..	5·97		
„ nitrogen	..	..	1·47	..	0·85		

TABLE III.—ANALYSES OF WATERS.

(Expressed in parts per 100,000.)

—	No. 1 Water. Rivington.	No. 7 Water. Loch Katrine.	No. 9 Water. Dee, Aberdeenshire.	No. 12 Water. Vyrnwy.
Total solids	10·16	3·61	6·1	3·98
Loss on ignition	2·74	1·18	1·9	1·05
Alkalies	1·06	0·501	1·36	0·518
Magnesia	0·461	0·205	0·256	0·127
Lime	1·735	0·509	0·48	0·706
Oxides of iron	0·016	Fe_2O_3 0·002; FeO None	None	0·099
Manganese oxide	0·017	None	None	0·059
Chlorine, combined	1·5	0·711	1·14	0·6
SO_3 combined	2·144	0·435	0·476	0·6
Silica	0·463	..	0·361	0·214
Total mineral matter	7·417	..	..	2·923
CO_2 combined	None	0·308	..	None
Organic carbon	0·343	0·21	..	0·498
,, ,, after filtration	0·323	..	..	0·331
Organic nitrogen	0·064	..	..	0·064
,, ,, after filtration	0·052	..	..	0·042
N as nitrates	Trace	0·005	0·02	0·109
Acidity (as CaO)	0·19	Almost neutral; alkaline after boiling.	Alkaline.	0·2
Oxygen, per litre	..	..	..	5·45 c.c.
Nitrogen gas, per litre	..	..	..	11·53 c.c.
CO_2	..	..	..	None

TABLE III. (*continued*).—ANALYSES OF WATERS.

—	No. 2 Water. Elan Valley.	No. 3 Water. Another Welsh Valley.	No. 4 Water. Ireland.	No. 5 Water. Ireland.	No. 6 Water. Lancashire.	No. 13 Water. Taff.	No. 14 Water. Montgomeryshire.	No. 15 Water. Ontario.	No. 17 Water. Lancashire.
Total solids . .	5·44	5·6	6·72	9·92	34·8	4·8	16·06	18·48	10·44
Loss on ignition .	..	..	3·04	4·52	..	..	..	5·16	..
Oxides of iron . .	Fe_2O_3, 0·016; FeO, None	Small quantity	0·004	0·008	Trace	Small quantity	Trace	0·006	Small quantity
Manganese oxide .	Trace	Trace	..	..	Trace	Trace	None	None	Trace
Chlorine, combined	..	..	..	..	3·0	..	..	..	1·3
CO_2 combined . .	0·46	..	0·176	..	..	None	Large quantity	..	None
Organic carbon .	..	0·6	..	..	1·109	..	..	..	..
„ nitrogen .	..	0·1	..	..	0·124	..	..	..	..
Acidity (as CaO) .	0·225	0·22	Acid before boiling; alkaline after	Alkaline	Alkaline	Slightly acid	Alkaline reaction	Alkaline	Slightly acid
Hardness . . .	2·21°	..	1·95°	4·03°	14°	..	..	..	..

(*Paper No. 3460.*)

"The Purification of Water highly charged with Veget Matter; with Special Reference to the Effect Aeration."

By Osbert Chadwick, C.M.G., M. Inst. C.E., and Bertram Blo Assoc. Inst. C.E.

In this country, and in most European countries, the wa supply of large towns is usually obtained from rivers flow through cultivated districts, or from gathering-grounds situ in remote or barren places; or, more rarely, from deep wells. well-water is usually pure, and need not be considered here. river-water, if, as is common, somewhat contaminated, is poll with the sewage of towns above the intake, and by the sur drainage from manured and cultivated land; the chief impur to be looked for and removed are thus of animal origin. water from mountain streams and moorland gathering-ground free from sensible contamination of this kind, but may con organic matter of vegetable origin, usually of a peaty chara In temperate climates, however, the quantity of such matt usually not excessive, and at worst causes the water to hav peaty colour and flavour. On account of the temperate clim and of the fact that the gathering-grounds are situated in l and unfertile regions, there is no liability to great and suc growth of vegetation, followed by swift decay and conseq communication to the supply of the semi-oxidized product vegetable refuse.

But in tropical and sub-tropical countries growth and d of vegetation are of a rapidity and on a scale which have parallel in temperate latitudes. If the débris from this d finds access to the water-supply, serious organic contamina result. It is evident that the probability of such cont

nation is much enhanced when the water is in a state of semi-stagnation, as may happen in a watercourse flowing slowly through marshy ground, or spreading into shallow pools. Much greater is the risk when the water is impounded in some large shallow pond, through which the flow is inconsiderable compared with the volume retained. When, on the other hand, the stream is brisk, and receives water from sources which are not commonly stagnant, the amount of vegetable impurity will be much reduced. It is found by experience that water of satisfactory quality can be collected from gathering-grounds covered with tropical vegetation, provided that there is no considerable contribution of water which has been stagnant in contact with decaying vegetable matter. The situation may be summed up by saying that, though a tropical water is not necessarily a bad water, yet it has, under like conditions of collection and storage, a larger opportunity of acquiring products of vegetable decay than has a similar water in a temperate region. Cases can be cited of all grades of water illustrating this point, from the best to the worst. It is to the worst cases, and to the treatment which the Authors have found appropriate, that they direct attention in this Paper.

Water containing a large amount of vegetable matter in solution is neither pleasant nor safe as a potable fluid. It is generally conceded that, though not always unpalatable, such water causes various stomachic complaints, notably diarrhœa; disorders of the kind have been observed with moorland waters of even non-tropical countries. This is the normal quality of tropical waters which have remained long in contact with growing and decaying vegetable matter. But at times—generally seasonal—there are great and relatively sudden alterations of the character of this vegetable-laden water. From being merely somewhat peaty and unattractive it may become positively offensive, with a stale fishy odour, and altogether undrinkable. The cause of this change is not certainly known, but it is probably to be traced to bacterial activity. With these conditions in view, it will be seen that to advise on the use and purification of tropical waters of this class is no easy task.

Character and Composition of Waters highly Charged with Vegetable Matter.

There is a striking similarity in the class of waters referred to, even though their places of origin are thousands of miles apart, and the local conditions by no means identical. The main

governing causes appear to be a profusion of vegetable life quicl growing and rapidly decaying, and exposure of the water ir stagnant or semi-stagnant state to contact with the débris fr these life-processes. Analyses of various samples from tropical a sub-tropical countries, given in the Paper and in Appendix I., se to illustrate both this similarity and the difference which is to observed between waters flowing freely and others semi-stagna In the first place, as a contrast to the highly charged waters ab to be described, certain samples from Grenada will be conside analyses of which have been made for the Government by Profes Harrison. They will suffice to show that water collected, as w these samples, in tropical districts and from land laden with ve table growth of all kinds, is not necessarily polluted with produ of decay: the possibility of that pollution no doubt existed; but occurrence was prevented by the absence of areas of stagnatior the sources of supply. The following are the chief figures in analyses which are of significance for the present purpose:—

GRENADA.

—	Samples.	
	No. 1.	No. 2.
	Grains per Gallon.	Grains per G
Total solids	7·50	8·50
Chlorine	0·71	0·85
	Parts per 100,000.	Parts per 10
Free ammonia	0·002	0·001
Albuminoid ammonia	0·004	0·003
Oxygen absorbed (in 4 hours)	0·061	0·037
Nitrogen as nitrites	Nil	Nil
" " nitrates	0·001	0·024
Hardness	3·8°	5·2°

These are both waters from running streams without stag places, and are substantially pure; they may be usefully comp with examples about to be given, and especially contrasted those other tropical waters which are at the opposite end of scale of purity.

That this condition of relative freedom from vegetable cont nation is not uncommon, even in waters taken from sources rounded by tropical vegetation, is shown by the following anal by one of the Authors:—

MOMBASA.

—	No. 1. Hill Stream.	No. 2. Stream in Main River (above Hill).
	Grains per Gallon.	Grains per Gallon.
Total solids	14·98	15·96
Chlorine	3·99	2·95
	Parts per 100,000.	Parts per 100,000.
Free ammonia	0·006	0·002
Albuminoid ammonia	0·003	0·014
Oxygen absorbed (after 4 hours)	0·06	0·11
Nitrogen as nitrites	Nil	Nil
„ „ nitrates	Nil	Trace
Hardness	3°	3°

Both these samples are from running streams. The first, indeed, is from an actual spring; the second is from a moderately swift stream, in which, however, there are some pools; it flows through a dense forest. The first is sensibly pure, but the second already gives signs of that class of contamination which will be shown later to be characteristic of tropical waters that have had opportunity of receiving the products of vegetable decay. The amount of free ammonia is low, that of the albuminoid ammonia is somewhat high, and that of the oxygen absorbed is substantial. There is an almost complete absence of oxidised nitrogen. These points are emphasized in the case of the following sample:—

RIVER PEMBRA.

(Shimba Hill Source.)

	Grains per Gallon.
Total solids	15·40
Chlorine	4·37
	Parts per 100,000.
Free ammonia	0·002
Albuminoid ammonia	0·015
Oxygen absorbed (after 4 hours)	0·20
Nitrogen as nitrites	Nil
„ „ nitrates	Nil

Hardness, 4·5°

The characteristically high albuminoid ammonia and oxygen absorbed occur here, and the equally characteristic absence of oxidised nitrogen is to be noted. The water is quite typical of its class. Other and more striking examples are given in Appendix I.

Comparison of a Tropical and a Non-tropical Water.—It has already been pointed out that the conditions of copious growth of

vegetable organisms, of their rapid decay, and of ample opp tunity for absorption of the products of decay by the water, det mine the character of the contamination acquired by that wat In illustration of this point, two cases, dissimilar in all but the essential respects, may be cited.

One of the waters in question was collected from a pond Rowledge, near Farnham, in Surrey. The other is from the Ma aux Vacoas, in the island of Mauritius. The two places are different as can well be conceived, save for the fundamental fa (1) that they are exposed to the ingress of vegetable refuse, (that they are almost stagnant, and (3) that they are subject little or no animal pollution. A more detailed description of t situation of the pond at Rowledge is given in Appendix II. (p. 4 In Appendix III. is a full account of the Mare aux Vacoas. He it will be sufficient to quote the analyses of the two waters.

——	Rowledge.	Mauritius.
	Grains per Gallon.	Grains per Gal
Total solids	8·40	5·82
Chlorine	1·67	1·27
	Parts per 100,000.	Parts per 100,
Free ammonia	0·004	0·002
Albuminoid ammonia	0·064	0·064
Oxygen absorbed (4 hours)	0·64	0·42
Nitrogen as nitrites	Nil.	Nil.
„ „ nitrates	Nil.	Nil.
Hardness	3·5°	2·5°

It is fortunate that it is rarely necessary in this country, or Europe generally, to have recourse to water-supplies of this scription; otherwise the difficulties of treatment about to described in the case of the Mauritius water would be encounter though doubtless in a less acute form.

The Treatment and Purification of Waters highly Char with Vegetable Matter.

The treatment and purification of waters of this class constit one of the most difficult problems which can be set before waterworks engineer and chemist. If, in addition, the site of supply is tropical, provision must be made to allow of alteration method according to seasonal fluctuation in quality. The maxim of impurity to be dealt with is far in excess of the mean, and

devising the process and designing the plant this condition must be held steadily in view. The Authors have had the advantage of closely studying methods devised and put into use by one of them at the Mare aux Vacoas Waterworks in Mauritius, and for the last 10 years they have from time to time endeavoured to improve the process both in principle and in detail. The methods adopted, and their general adaptability to similar waters, can best be understood after consideration of the situation and history of the Mare aux Vacoas.

The Mare aux Vacoas, Mauritius.—This lake was originally a morass surrounded by semi-tropical forest. It had a comparatively small area and depth, and was fed by numerous streams coming from a wooded district. The surplus water flowed into the Tamarind River. The area of the lake was increased by the construction of a dam, and the enlarged area was never cleared, the trees and scrub being immersed and ultimately dying and decaying. On account of the immersed and decaying vegetable matter, considerable difficulty has been experienced in purifying the water to a satisfactory point. The difficulty was increased by the fact that a large population was dependent on the water of the Mare aux Vacoas, and therefore the supply could not be suspended even for a short time.

The method of improvement adopted by one of the Authors was as follows :—In the first place the water-level was lowered to the greatest extent compatible with the maintenance of the supply, and a contoured survey of the lake was made. The banks were cleared of trees and vegetation of all kinds to low-water line, and up to about 10 feet above high-water. The "voons" (a water-plant) were cut as close to the bottom as possible, and their roots and the stumps of "vacoas" (screw-pines) were torn up by a steam grab-dredger.

According to the scheme originally devised, the sill of the sluice for compensation-water and that for the supply were at about bottom water-level (or zero of the Mare gauge). Thus the water for consumption was drawn from the lowest and most contaminated stratum. The compensation-sluice, though properly placed as regards depth, was so small that it could not discharge enough water even in a moderate flood; and the pure incoming rain-water poured over the Tamarind dam instead of displacing the contaminated water and being itself retained. The defect was remedied by constructing a large sluice in solid ground on the north flank of the Tamarind dam, 10 feet wide, with its sill 1 foot below the zero of the Mare aux Vacoas gauge, and closed by a Stoney sluice.

All compensation-water is therefore now drawn from the low strata of the reservoir, and the area of waterway is sufficient discharge the surplus water in all but extraordinary floods. raising the sluice the dam may be prevented from overflow during normal wet weather, and surplus water escapes from lowest strata of the reservoir, not from the surface as bef A new outlet, in the form of a circular chamber provided w sluices arranged in steps, so that the supply could always be ta off within 1 foot of the surface, was constructed at the north enc the reservoir. Passages were formed for the principal strea feeding the Mare, and all shallow areas of contaminated mar water were banked off. A depositing-reservoir, with a capacit 1,000,000 gallons, and four filter-beds, each having an effect area of 7,200 square feet, were constructed below the Mare. Th works, which were carried out under the direction of Mr. E. Brine, Assoc. M. Inst. C.E., as Resident Engineer, assisted by Paul le Juge de Segrais, Assoc. M. Inst. C.E., produced a marl result. The water, which at first was hardly filterable, became under normal conditions. In dry seasons, however, grave inc venience was experienced. The water which, though sligh coloured and turbid, was not objectionable or undrinkable bef filtration, developed after filtration an offensive fishy smell. On t account recourse was had to a chemical method of purification.

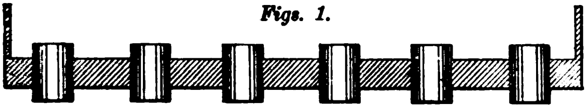
Preliminary trials had shown that the water could be materia improved by agitation with iron. Further experiments est lished that the water could be brought to a satisfactory condit by treatment by the Anderson process, if it were afterwa adequately aerated. Many other processes were tried, but w not equally successful. The improvement of the water af treatment with iron is shown by the following analyses:—

——	Untreated Water (1892).	Untreated Water (1901).	Treat Wat
	Grains per Gallon.	Grains per Gallon.	Grains Gallo
Total solids	6·91	5·32	..
Chlorine	0·98	1·27	..
	Parts per 100,000.	Parts per 100,000.	Parts 100,0
Free ammonia	0·029	0·002	0·0
Albuminoid ammonia	0·031	0·064	0·0
Oxygen absorbed	0·43	0·42	0·1
Nitrogen as nitrites	Nil	Nil.	..
" " nitrates	Trace	Nil.	..
Hardness	1·5°	2·5°	..

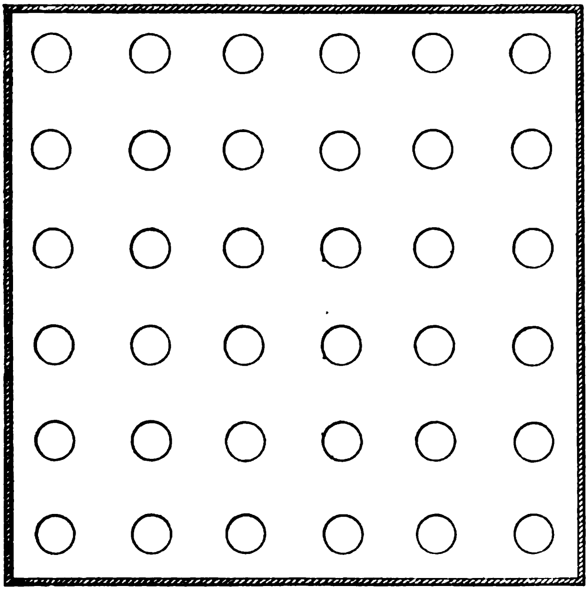
Owing to the fact that this water contains a large quantity of organic matter, the amount of iron necessary for its purification is large; and the precipitation of this iron can be accomplished only if the water is thoroughly aerated after passing through the Anderson apparatus. The usual method of allowing the water to fall over terraces or cascades is not sufficient; the area thus exposed is too small to ensure that the water shall be saturated with air.

Experiments on Aeration.—In order to increase the area exposed

Figs. 1.



SECTION

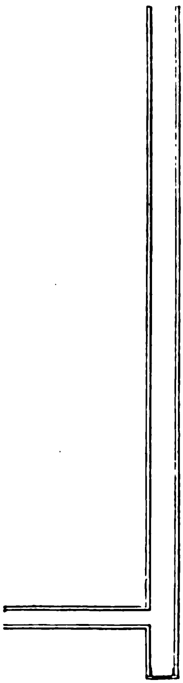


PLAN

various devices were tried. These included the use of plates with holes having a raised margin, as shown in *Fig. 1*, and of such a diameter (*e.g.* ½ inch) that the water flowing over the margin fell in isolated drops; the principle of the Lunge plate-tower (*Figs. 7*) was also used experimentally. But these methods did not promise a successful result. The quantity of water that could be treated

with a given area of plate was too small; and it was found diffi to adjust the level of a large number of orifices so exactl to ensure an equal flow through each. After many experim the simple device of allowing the water to issue in thin cylin cal streams, thus exposing a surface relatively large, was adop

Fig. 2.



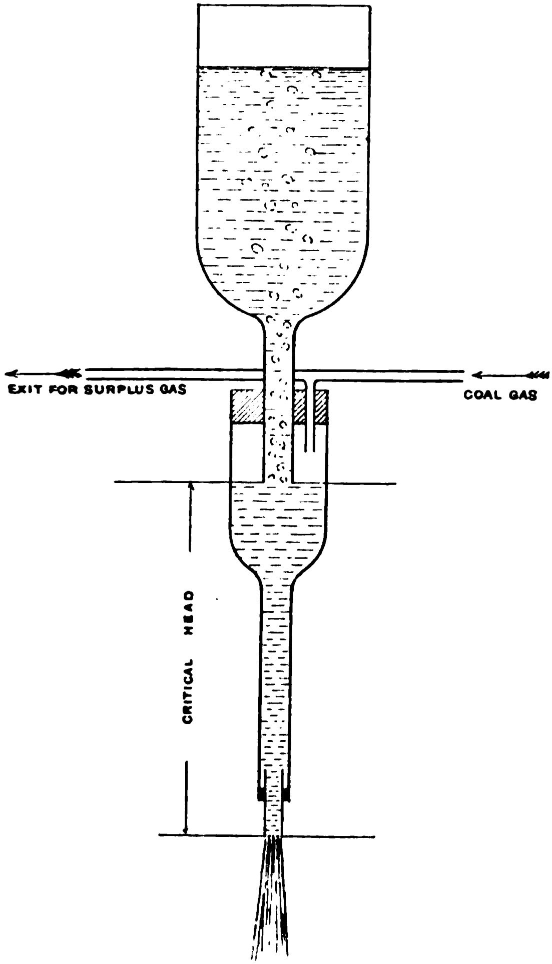
It was found by trials made with glass tı closed at the lower end by a perforated pl as shown in *Fig. 2*, that when the w flowed through the holes under a small h *e.g.*, 2 or 3 inches, the issuing jets from a cent holes coalesced in a thick, rope-like stre thus presenting a greatly reduced surface absorption of oxygen. Naturally this more likely to occur the more closely the h were pitched. As it was desired that aerating apparatus should be compact, it necessary that the pitch should be moder and yet the streams of water must not together. Further trial showed that, fo given size of orifice, there was a cer critical head below which the streams wc coalesce if by chance they touched e other. At and above the critical head, streams separated spontaneously, even if t were intentionally caused to touch fo moment. It follows that the proper work of an apparatus made on this principle, discharging jets in the open air, will be c temporarily disturbed by a gust of wind other cause which may deflect the strea provided that the water is being discharge a pressure not less than the critical head.

The critical head for holes of various diameters, and the ı of flow for each, were determined, with the following results :–

Size of Hole.	Diameter.	Critical Head.	Rate of Flow per H under critical Head
S.W.G.	Inch.	Inches.	Gallon per Hour.
No. 19	0·040	8	0·87
,, 20	0·036	11	0·83
,, 21	0·032	12	0·67
,, 22	0·028	16	0·52
,, 23	0·024	22	0·52

It was also necessary to decide what size of hole and what fall were requisite, in order to aerate the water thoroughly. Accordingly, water which had been freed from dissolved air was allowed to flow through perforated plates fixed in the experimental

Fig. 3.

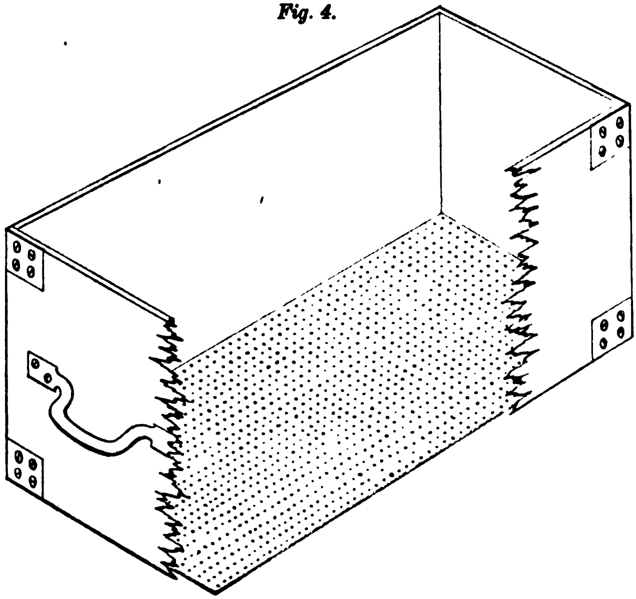


apparatus shown in *Fig. 3*: the air-free water was protected from premature contact with air by being surrounded with an atmosphere of coal-gas. After falling through the prescribed distance it was caught, and the quantity of oxygen which it had absor'

during its fall was determined. The results showed that ab tion was practically complete in a fall of 6 feet, the water being nearly saturated with oxygen. It was also found that altho as might be expected, the smaller jets were somewhat rapid in their aerating effect, yet a comparatively coarse *e.g.*, 0·04 inch in diameter, was quite efficient. For prac reasons a fairly large orifice is preferable, as it is less liable t choked by fine suspended particles which may be contained ir water.

Aeration Apparatus.—These experimental results took wor

Fig. 4.

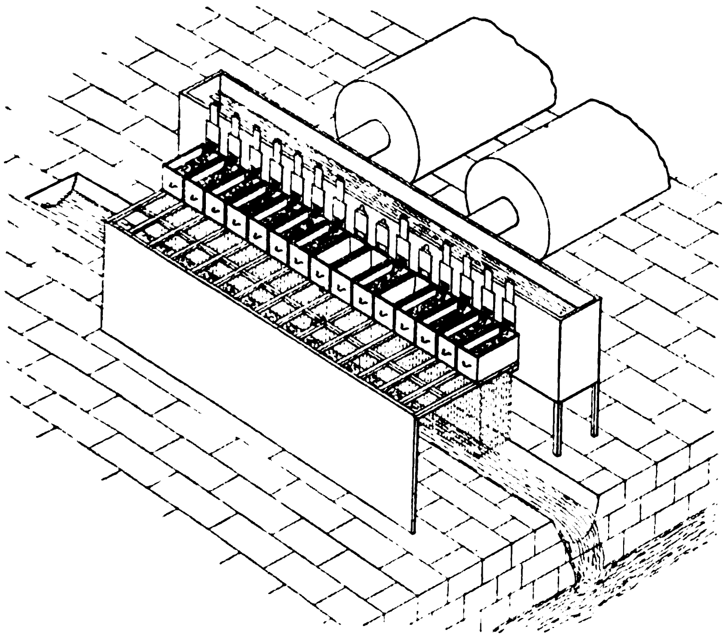


shape in the following way:—A number of trays or dra 2 feet by 1 foot by 1 foot, were made of teak, the botto each consisting of a delta-metal plate $\frac{1}{8}$ inch thick and pi with numerous orifices pitched $\frac{1}{4}$ inch apart (*Fig. 4*). T were thus 4,584 orifices in each drawer, discharging co tively 3,988 gallons per hour. In all, fifteen drawers provided, capable of handling 1,000,000 gallons per 24 h proper allowance being made for some being out of use for c ing during that time. Each tray could be removed, turne end, and cleaned with a hose or brush without interfering

the working of the rest of the apparatus. The water to be aerated, after passing from the Anderson revolving purifier, was allowed to flow into a distributing-trough and thence through small sluices into the boxes. The arrangement of the whole apparatus is shown in *Fig. 5.* The opening of each sluice could be adjusted so that the box beneath it was kept filled to or slightly above the critical head of 8 inches.

The result of the treatment with iron by the Anderson process, followed by the special method of systematic aeration employed,

Fig. 5.



ARRANGEMENT OF AERATION APPARATUS AT MAURITIUS.

has been to make the water filterable at all seasons of the year.[1] The filtrate is free from the disagreeable taste and smell which formerly made it unfit for drinking and domestic use. The use of iron as a precipitant is unquestionably valuable, but its value

[1] Some difficulty was experienced in the season 1899–1900 when a serious drought occurred and the water was exceptionally impure; at that time, however, the supply of air to the revolving purifier was inadequate. This has si- been remedied, and in 1901 and 1902 no trouble arose.

would not be effectively attained if it were not aided by thorough aeration. The function of the oxygen imparted to the water by the aerating apparatus is two-fold; first, to oxidise the ferrous compounds and to induce precipitation of a great part of the organic matter by the ferric hydroxide resulting from this oxidation; secondly, to destroy residual organic matter during the passage of the water through the filters. The great importance of this second stage is proved by observations made in Mauritius by Mr. le Juge de Segrais on the effect of intermittent filtration. Before the present apparatus was fully at work, he found that in the dry season, when the water was loaded with organic matter, it acquired a fishy taste and smell during its passage through the filters. He also found that this could be prevented, and a good filtrate could be obtained, if the filters were worked intermittently, allowing ample time for their aeration. In Mauritius local conditions forbade the adoption of this simple method; but it is noteworthy as emphasizing the advantage of copious and controlled addition of oxygen to a water loaded with organic matter difficult of removal. When the cost of construction of spacious filter-beds is not prohibitive, this particular method of oxygenation may be applied with good effect. A case in point is that of the waterworks at Singapore, where an excellent system of intermittent filtration has been elaborated by Mr. S. Tomlinson, M. Inst. C.E., late Municipal Engineer of the town. Being confronted with a difficulty similar to that which was encountered in Mauritius, Mr. Tomlinson found that he could prevent the occurrence of the fishy smell and taste of the water by working filters at such intervals as to allow of their aeration. Mr. Tomlinson has been kind enough to communicate to the Authors his experience in this matter, and the result of his observations is given in Appendix IV. (p. 42).

Purification of Water from Nairobi River, Uganda.

The process devised for Mauritius was put to work and proved successful. In consequence, the principle was applied in a case of even greater difficulty. The water of the Nairobi River in Uganda is considerably worse than that of the Mare aux Vacoas in Mauritius. The analyses on p. 31 are sufficiently illustrative.

So impure a water is quite unfit for drinking, and requires elaborate methods of purification. Many experiments were tried, and finally the following process was selected:—The water is passed through an Anderson revolving purifier of ample size, and is there treated with a large volume of air. By this treatment it

UGANDA (NAIROBI RIVER).

—	1	2	3
	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.
Total solids	20·86	23·83	13·58
Chlorine	2·37	2·37	1·73
	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.
Free ammonia	0·008	0·004	0·020
Albuminoid ammonia	0·044	0·060	0·020
Oxygen absorbed (4 hours)	1·22	1·14	0·20
Nitrogen as nitrites	Nil	Nil	Nil
„ „ nitrates	..	..	..
Hardness	..	..	3·50

is caused to dissolve a considerable quantity of iron. The ferruginous water is aerated by passage through a series of trays precisely similar to those employed in Mauritius, except that they are made of galvanized iron, wood being attacked by the white ant. The aerated water flows into settling-tanks and there deposits the bulk of the dissolved iron. Complete purification, however, is not accomplished by this single treatment, which suffices for the Mauritius water.

A certain amount of the organic matter, and probably even some of the iron, remains in solution and must be removed. This is done by precipitation in a second set of tanks with a small quantity (about 1 grain per gallon) of aluminium sulphate and its equivalent of lime. The precipitate is allowed to settle, and the fairly clear water is finally filtered through a "Torrent" filter. *Figs.* 6 illustrate the essential parts of the plant. The improvement effected by this treatment is shown by the following analyses :—

ANALYSES OF SAMPLE OF WATER FROM NAIROBI RIVER.

Before Purification.

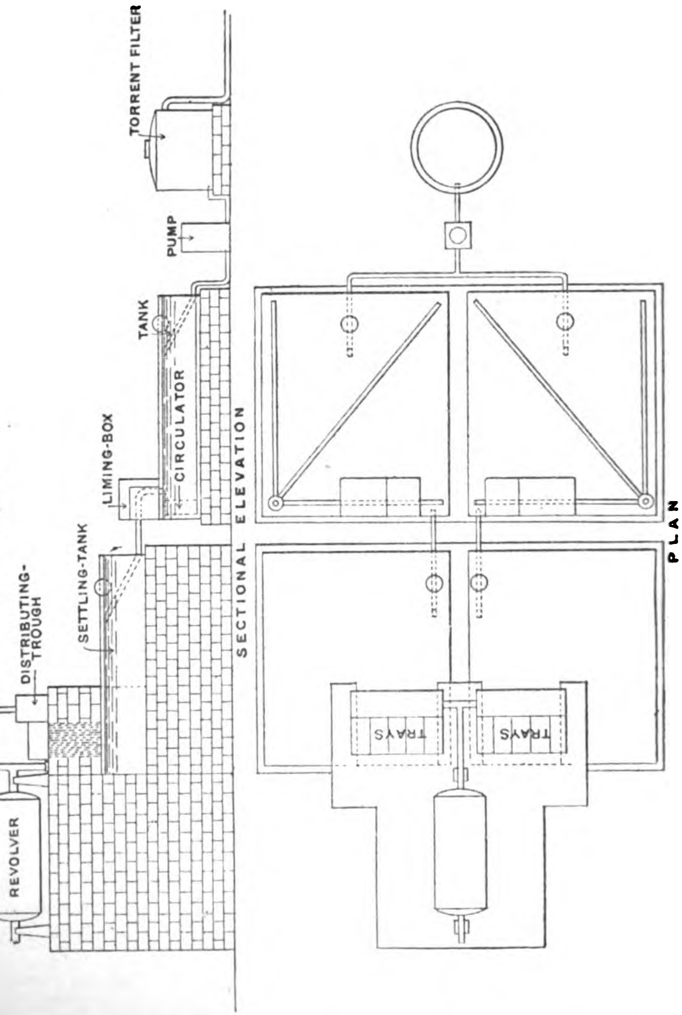
	Grains per Gallon.
Total solids	13·58
Chlorine	1·73
	Parts per 100,000.
Free ammonia	0·020
Albuminoid ammonia	0·020
Oxygen absorbed (after 4 hours)	0·20
Nitrogen as nitrites	Nil
„ „ nitrates	Nil

Hardness, 3·5°.

After Purification.

	Parts per 100,000.
Free ammonia	**0·112**
Albuminoid ammonia	**0·004**
Oxygen absorbed (after 4 hours)	**0·010**

Figs. 6.

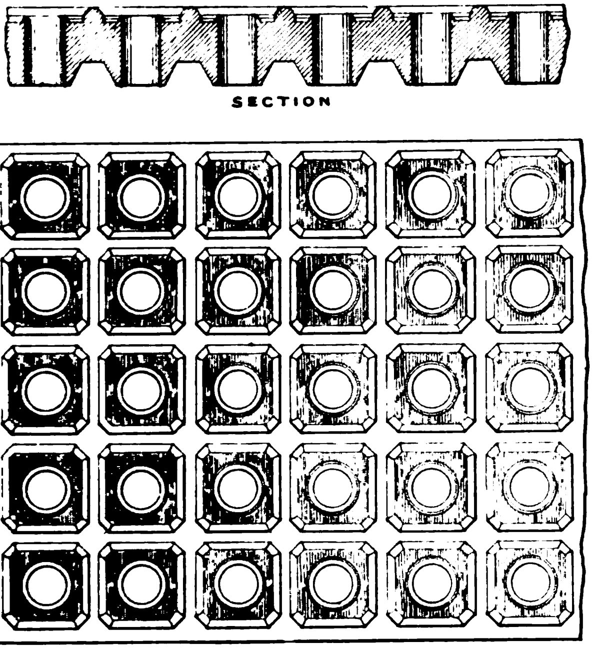


It will be seen that whereas the natural water is loaded wi
vegetable matter, the purified product is of good quality and qui
notable.

Possible Applications of the Aerating Process.

The foregoing method of aerating water in an effective manner by exposing slender jets to the air is, as far as the Authors know, novel. Its utility has been proved for the oxidation of waters containing iron artificially added. Obviously it will serve for the treatment of ferruginous water, and for this purpose it has been already adopted. There are other purposes for which it may prove

Figs. 7.



Lunge Plate.

to be useful. For example, in the treatment of sewage by the action of aerobic bacteria, oxygen necessary for the healthy life of the organisms is administered by intermittent filtration, the beds being emptied at intervals, and thus aerated. Various sprinkling devices are also adopted, both to distribute the sewage over the contact-beds, and incidentally to aerate it to some extent. It appears to the Authors probable that the necessary aeration may be more effectively attained if the sewage, freed fro-grosser particles of suspended matter, is caused to flow in t

individual streams through a perforated plate under a critical head. The holes, if as small as those used by the Authors for the treatment of water, may become choked too readily, and a somewhat larger size may be requisite; in any case, however, the trays are so easily removed and cleaned without stopping the working of the apparatus as a whole, that the difficulty is not likely to be serious unless the previous subsidence and screening of the sewage should prove to be impracticable.

Another suggested application is for the cooling of condenser-water. Where there is no space available for a cooling-pond it is usual to pump the hot water from the condenser over a pile of brushwood or similar arrangement, so that the water may be cooled by its own evaporation. Evidently this somewhat crude and cumbrous apparatus might be replaced by a set of perforated plates with a considerable saving of space and increased efficiency of working.

The primary purpose for which the apparatus was devised was the treatment of water with air; obviously it is suitable for the treatment of liquids with gases generally; such operations are frequently needed in chemical industry. Conversely it is fitted to treat gases with liquids, *i.e.* to act as a scrubber. In many chemical manufactures the old coke scrubber has been advantageously replaced by the Lunge plate-tower, which consists of a series of plates, each provided with perforations about ½ inch in diameter, and having a rim or collar, so that the liquid with which the gas is to be treated flows slowly and regularly over this lip, and drips down (*Figs. 7*). This apparatus has proved of great utility, but the Authors venture to think that in some instances, at least, the use of the finely-perforated plates described in this Paper, working under a critical head, may be found preferable.

This and the foregoing suggestions are merely mentioned as fairly vious applications of the principle which has been described. ch would require detailed study before a working apparatus s devised. For the treatment of impure water, however, of the ss which forms the subject of this Paper, the method is no longer a tentative stage; it has justified itself by the test of practical ility.

The Paper is accompanied by seven drawings, from which the igures in the text have been prepared, and by the following ppendixes.

[APPENDIXES.

APPENDIXES.

APPENDIX I.

A group of analyses of water from Antigua may be quoted in further illustration of the great influence of delay in flow, or of actual stagnation, on the amount of the degradation products of vegetable matter acquired by tropical waters.

ANTIGUA.

—	1 Water from Filter-Beds at Grays Hill before Filtration (mainly Spring-water, not Stagnant).	2 Water from Boddy Ponds; dry Season (Semi-stagnant).	3 Water from Middle of Reservoir Wallings; (Stagnant). Unfiltered.	4 Water from Middle of Reservoir Wallings; (Stagnant). Filtered.
	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.
Total solids	33·32	46·34	22·12	21·21
Chlorine	5·38	12·19	2·40	2·40
	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.
Free ammonia	0·003	0·005	0·004	0·003
Albuminoid ammonia	0·005	0·009	0·017	0·015
Oxygen absorbed (after 4 hours)	0·10	0·16	0·24	0·22
Nitrogen as nitrites	Nil	Nil	Nil	Nil
„ „ nitrates	Nil	Nil	Trace	Trace
Hardness	9·5°	11°	4°	4°

It will be seen that the stagnant condition of the third sample has caused it to acquire an amount of vegetable pollution which is not only relatively large, but is evidently difficult of removal by ordinary filtration. It is this difficulty of removal which is so serious a matter in the selection and purification of a tropical water-supply.

The facts set forth above receive corroboration from a large number of analyses which the Authors have been led to make from time to time of waters from various tropical regions. Some of the more interesting of these, from African sources, are recorded in the Tables on pp. 36–39, namely, samples from Cape Coast Castle, Accra and the Victoria Nyanza.

Sweet River is a perennial stream about 30 feet wide at the point where the samples were taken, coming down from a country covered with dense bush and scrub. Although the river itself is fairly swift, it forms large pools at intervals, and in these the flow is naturally sluggish. Such conditions go far to account for the presence of the relatively large amount of vegetable contamination in all the samples disclosed by the analysis. The water as it stands cannot be considered potable, but it must not be concluded that a potable supply is

CAPE COAST CASTLE.

Sweet River.

—	Taken during Rainy Season.					Taken during Dry Season.			
	1	2	3	4	5 Pool with little Current.	6	7	8	9
	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.
Total solids . . .	9·94	13·30	6·16	6·30	6·86	10·08	11·76	13·16	11·62
Chlorine	1·13	1·14	0·86	0·86	0·77	2·55	4·16	3·08	3·22
	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.
Free ammonia . .	0·036	0·026	Nil	0·002	0·034	0·040	0·100	0·120	0·020
Albuminoid ammonia	0·061	0·108	0·032	0·028	0·038	0·200	0·040	0·020	0·020
Oxygen absorbed .	1·33	1·82	0·66	0·64	0·69	0·71	0·74	0·72	0·47
Nitrogen as nitrites	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
,, ,, nitrates	,,	,,	Trace	Trace	Trace	,,	,,	,,	,,
Hardness . . .	4·0°	3·0°	2·5°	2·0°	2·5°	3·0°	3·0°	2·5°	3·0°

ACCRA.

Various rivers and springs.

—	1 Insuasi River (clear running Stream).	2 Spring.	3 Spring.	4 Pool near Iheem (near Marsh).	5 Papoo Stream.	6 Papoo Stream.	7 Adjamenta Stream.	8 Adjamenta Stream.	9 Adjamenta Stream.	10 Iheem Stream.
	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.	Grains per Gallon	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.
Total solids	13·16	7·98	6·16	17·08	14·00	14·84	10·78	10·64	10·78	17·78
Chlorine	3·26	2·78	1·92	4·70	2·22	2·42	2·42	2·18	1·84	3·67
	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.
Free ammonia	0·002	0·004	0·002	0·056	0·003	Trace	0·001	Trace	Nil	Trace
Albuminoid ammonia . .	0·008	0·010	0·008	0·030	0·026	0·013	0·023	0·027	0·035	0·050
Oxygen absorbed . . .	0·18	0·08	0·04	0·47	0·74	0·15	0·60	0·36	0·57	0·75
Nitrogen as nitrites . . .	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
„ „ nitrates . .	0·36	„	„	„	„	„	„	„	„	„
Hardness	3·5°	2·0°	3·0°	8·0°	2·75°	3·0°	2·5°	1·5°	2·0°	2·5°

[illegible]

[illegible]

—	River Molo.	Nairobi River.	Nairobi River.	Nairobi River.	River Athi.	Lake Nakuro.	Spring near Lake Nakuro.	Springs near Ziwani.
	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.
Total solids	12·46	20·86	23·83	13·58	17·64	257·46	25·90	13·02
Chlorine	0·76	2·37	2·37	1·73	2·02	31·92	1·14	2·02
	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.	Parts per 100,000.
Free ammonia	Nil	0·008	0·004	0·020	0·016	0·094	Trace	0 032
Albuminoid ammonia . . .	0·030	0·044	0·060	0·020	0·036	0·028	0·006	0·028
Oxygen absorbed (4 hours) .	0·55	1·22	1·14	0·20	0·85	2·25	0·15	0·10
Nitrogen as nitrites	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
,, ,, nitrates	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Hardness	..	..	..	3·5°	3·5°	..	..	3°

unprocurable from this source. A great improvement can doubtless be effected by clearing the margins of the springs and watercourses, and by so straightening and deepening the channels that the water is no longer imprisoned in stagnant pools exposed to the débris of all sorts of extinct vegetable life. It is not the abundance of tropical vegetable life in itself which is harmful, but its rapidity of decay, and the opportunity for the absorption of the products of this decay, which affect injuriously the purity of the water.

The gathering-ground of the Adjamenta stream, Accra, is a valley about 900 feet above sea-level, about 6 miles long, and having an average width of 1½ mile. Numerous tributaries feed the main stream, which leaves the valley by a narrow neck and passes over a series of falls. The water in its present condition cannot be pronounced good, but in this instance the causes are local rather than general. Various native villages and palm-oil factories contribute a good deal of contaminating matter, but it is probable that some at least is derived from the presence of stagnant pools and marshy places on the main stream and its tributaries.

Victoria Nyanza.

	Grains per Gallon.
Total solids	16·38
Chlorine	0·86
	Parts per 100,000.
Free ammonia	0·026
Albuminoid ammonia	0·130
Oxygen absorbed (after 4 hours)	0·61
Nitrogen as nitrites	Nil
„ „ nitrates	Nil

Hardness, 3°.

Mineral Analysis.

	Grains per Gallon.
Silica (SiO_2)	0·71
Oxide of iron and Alumina ($Fe_2O_3 + Al_2O_3$)	0·18
Lime (CaO)	0·91
Magnesia (MgO)	0·79
Soda (Na_2O)	3·16
Carbon dioxide (CO_2)	2·88
Sulphur trioxide (SO_3)	0·15
Chlorine (Cl)	0·86
	9·64
Oxygen for Chlorine	0·19
	9·45
Water, etc.	6·93
Total solids	16·38

Chief Salts.

	Grains per Gallon.
Calcium carbonate ($CaCO_3$)	1·62
Magnesium carbonate ($MgCO_3$)	1·66
Sodium carbonate (Na_2CO_3)	3·13
Sodium sulphate (Na_2SO_4)	0·27
Sodium chloride ($NaCl$)	1·42

The water last cited is noteworthy chiefly on account of its origin. The Authors are not aware that any previous analysis of the water of Victoria Nyanza has been published, and they thought the matter of sufficient interest to give a complete analysis of the mineral constituents as well as the ordinary organic data. For so huge a body of water, which could hardly be supposed to be influenced by any ordinary source of contamination, the water is remarkably impure. The Authors have no means of ascertaining from what portion of the lake or how far from shore this sample was taken. In the absence of this information it would be rash to assume that this highly polluted water is an average sample of the lake generally; but, however this may be, it is certainly remarkable that a source of supply which might naturally be regarded as unexceptionable can be, at least in parts, objectionably impure.

APPENDIX II.

Pond at Rowledge.

This pond is situated on the border of a large wood, in a shallow depression, with no perceptible incoming stream, and with sides sloping so gently that the rain collected by them flows but slowly into the pond. It is surrounded with vegetation growing freely and in quantity, and on the margin are a good many trees. The fields, which come down to the water's edge, bear grass abundantly, and there is a profusion of small, moisture-loving plants on the very edge, these being sometimes immersed when the pond is full. In the summer there is a rapid growth of true aquatic plants, spreading far out from the shore, and in places completely hiding the surface of the water. As the season passes, a part of these water-plants may be stranded by the shrinkage of the pond, and die prematurely in consequence; ultimately the whole crop perishes in the ordinary course of its life history. Thus there is left a large quantity of non-woody vegetable matter, slender stalks, and delicate leaves, rapidly rotting. The falling foliage of the trees on the margin contributes to the mass of decaying material finding its way into the waters of the pond. All these phenomena are at their height after a period of hot dry weather, and it was at the end of such a period that the sample was taken of which an analysis is given in the Paper.

APPENDIX III.

Description of the Mare aux Vacoas.

he Mare aux Vacoas (Marsh of screw-pines *Pandanus Vacoas* or *P. Sativa*) uated in the central plateau of Mauritius at an elevation of about 1800 bove sea-level.

n one of the Authors first saw it in 1891, it had already been converted storage-reservoir by the construction of a dam, about 7 feet high and long, across its principal outlet to the Tamarind River, thus making a reservoir, havin[illegible] 237 acres. The gathering-ground of the Vacoas ha[illegible] 5 square miles, all now Government forest ultivat[illegible] The only large animals on the gathering-

ground are a few sambur deer. The water collected in the Mare reservoir is therefore above suspicion as regards sewage contamination. The gathering-ground is covered with bush, with occasional trees of considerable size.

The average rainfall is about 130 inches, well distributed throughout the year. Indeed, a wholly rainless month is unusual, and for about 8 months in the year a wholly rainless day is almost an exceptional circumstance. During the cyclone season, January to March, very heavy downpours occur.

The gathering-ground leaves nothing to be desired as to freedom from pollution, and the occurrence of a natural marsh and lake proves the existence of an impervious bottom. Thus, many important conditions for the construction of an impounding-reservoir and for the provision of an ample and good water-supply were present. The drawback to the Mare aux Vacoas as a reservoir-site was its flatness, and the gently sloping character of its margin, which rendered it impracticable to make a fairly deep reservoir, except perhaps at a prohibitory cost. Unfortunately, the site was not cleared of vegetation. The whole of the land submerged was left absolutely untouched.

When one of the Authors first saw the Mare aux Vacoas, it presented the appearance of a green meadow. Standing on an eminence, at the western extremity of the reservoir and looking eastward, this green plain was visible, with a small patch of dark water in its midst, probably the deep part which formed the natural lake already referred to. In the middle distance there was a large clump of forest trees killed by the submergence of their roots, and rotting as they stood in the water. At the eastern extremity, there was a flat tract covered with tussock-grass and low bushes partially submerged, but the bushes were not yet killed.

The water was of a brown peaty colour. Viewed in the 2-foot tube, it was nearly opaque, and of a dark brown, almost porter-like colour. An experimental sand-filter 6 feet square was made. The water proved to be practically unfilterable by the ordinary process of sand filtration, the sand becoming choked with glutinous matter in a few hours. Agitation with metallic iron produced a marvellous change. A marked brown precipitate was deposited. The decanted water was filterable, and the water, when seen through a 2-foot tube, was clear, and only slightly yellow in colour. Laboratory experiments subsequently made confirmed this observation and formed the basis of the method of purification described in the Paper.

The vegetation which invaded the water space consisted practically of one plant only, that known locally as "Voon." The botanical name of this plant is *Eleocharis*. It is a rush-like plant, having a creeping root-stalk firmly anchored to the bottom by rootlets. From this, long green shoots sprout and grow upward until their tips protrude about 12 to 18 inches above the water-level, when a small brush-like flower, of a brown colour, is developed, at the apex of the shoot. The shoot is devoid of leaves, it is smooth and cylindrical, about 3-16ths inch in diameter, hollow, with thin walls, and is divided into separate cells by diaphragms. When growing, these cells are entirely free from water, even at the greatest depths. When the voon shoot has reached maturity, and put forth its flower, it becomes water-logged and sinks to the bottom, where it slowly decays. Fresh shoots are then thrown off, penetrate the tangle of decaying shoots, and reach the surface. This growth and decay goes on perennially; so that in the natural state, there is a constant field of green voon densely packed below with a tangled mass of dead and decaying shoots. The maximum depth of water in which voon can grow appears to be about 10 feet.

In the Authors' belief, it is to the decay of voon that the strong impregna-

of vegetable matter is due. The bed of peat-like matter on the bed of the reservoir, the product of ages of decomposition also, no doubt, contributes largely to the contamination, as well as the roots and stumps of Vacoas and other plants killed by submergence.

APPENDIX IV.

Purification of the Water-Supply of Singapore.

Mr. S. Tomlinson, late Municipal Engineer of Singapore, has kindly communicated the results of his experience with the water-supply of that city. The water at Singapore occasionally possesses an objectionable smell, recalling that of sulphuretted hydrogen. The method adopted for removing this consists substantially of intermittent filtration. No special effort is made to aerate the water, but it happens that the pipes delivering into the well feeding the filters are turned upward, so that as the water flows in it is considerably agitated in contact with air.

From the well the water flows into the filters in the ordinary way. These are worked as usual in all respects, except that they are emptied and refilled fairly frequently, *i.e.*, every 4 to 14 days according to the season; the sand-bed is aerated for about 12 hours between the time of emptying and refilling. The rate of filtration is about 20 gallons per square foot per 24 hours, the time being that during which the filter is actually running. By this method it has proved possible to obtain regularly a satisfactory filtrate, even when the raw water is more than ordinarily impure.

Discussion.

The PRESIDENT, in moving a vote of thanks to the Authors, remarked that the Papers dealt with questions of great practical importance, and he was assured by friends who were experienced in such matters that they were likely to be of considerable value to future engineering practice in water-supply. The President.

Professor CAMPBELL BROWN placed on the table a typical specimen of what he called "limpets," and some called "barnacles," but which were really incrustations of iron. The incrustation was the colour of iron rust, but it had been quite black when fresh. He also exhibited a specimen of iron pipe with some of the incrustations still intact, showing the softness of the metal for some distance from the inner surface. The specimen seemed to be bright the whole way through, but that appearance was deceptive; when it was fresh the difference in the shade could be seen nearly half-way in. In spite of the apparent similarity in the colour and consistency a knife would cut into the inner surface, but not into the outer surface. Prof. Brown.

With regard to the Paper by Messrs. Chadwick and Blount, he would like to ask what quantity of iron was employed relatively to the quantity of water. Also, to call attention to the fact that oxygen dissolved in water with great rapidity, not to an extent of more than 6 cubic centimetres per litre in the case of atmospheric oxygen, but very rapidly; and therefore the chief use of the elaborate aerating apparatus was not really to get the water saturated with oxygen. There was confirmation of this view in the statement in the Paper that there was no advantage in making the orifice or the sectional area of the jet small. It would probably be found that the object accomplished by the apparatus lay in the oxidation of the impurities and not in the aeration of the water. A microscopic examination of the surface of the aerating apparatus after use might be useful. Presumably the action of the iron was somewhat as follows:—The iron dissolved, and formed a ferrous salt in solution; then the ferrous salt was oxidized and formed an insoluble basic ferric salt, carrying the impurities with it when allowed to settle, or when filtered.

Mr. CHADWICK exhibited a number of lantern slides illustrating the work carried out in Mauritius. Mr. Chadwick.

Mr. BLOUNT mentioned that whatever merit there might

Mr. Blount. the device of aerating water by allowing it to flow for thin streams was due to Mr. Chadwick, with whom he ha the advantage of working out the process.

Mr. Mansergh. Mr. JAMES MANSERGH, Past-President, thought that, in sayi his Paper that it was unwise to remove the incrustation ir pipes by scraping in the usual way with the hydraulic so Professor Campbell Brown had not quite appreciated the force objection to the deposit. In considering the matter the eng was on the horns of a dilemma. The Author had said that i pipe was scraped, its life was shortened; but if the pipe wa scraped its life was also shortened, because the pipe might incrusted that it would not convey one-fifth of the int quantity of water. With regard to deposits of carbonate of he had placed on the table a piece of pipe taken from one c Bath mains about 30 years ago. The bore of that pipe was two-thirds choked with a deposit of what was practically carbonate of lime, there being with it only a trace of magn but the pipe itself was perfectly sound. In the slime-deposi had been greatly interested for some time. It was no secret that the Liverpool Corporation had been very much exercis their minds a few years ago, on finding that the dischar capacity of their main between the reservoir at Vyrnwy an filter-beds at Oswestry had materially diminished—he believ as much as 20 to 25 per cent. Below the filter-beds, how practically no diminution of discharging-capacity had occu After investigation of the matter by the Corporation's engi Mr. Deacon had suggested that the deposit above Oswestry sl be removed by revolving brushes, and that had been done considerable success. About that time Mr. Mansergh had h lay two lines of large pipes, each 37 miles in length, for Bir ham; and it had been a matter of great importance tha experience of Liverpool should not be repeated. He had the obtained the authority of the Waterworks Committee of Birn ham to consult Mr. Parry, the Engineer of the Liverpool W works, Professor Campbell Brown, and Professor Rubert B who had willingly given him all the information they poss on the subject; and he was now taking measures whic hoped would prevent that deposit, so that there might n any necessity in the future to remedy it. Put in untech language, the substance of the information he had obtained that there was a certain organism (*Cladothrix*) in the water w attached itself in large numbers to the inside of pipes, and the power of attracting to it as a nucleus all fine mineral or

suspended matter in the water. The aggregations around the numberless organisms ultimately formed a united coating covering the whole surface of the pipe, which by reducing sectional area and increasing friction, diminished the effective discharge. With the Liverpool facts and the results of the experiments in his possession, and with the further knowledge that similar organisms were present in the Elan water, he had had to decide what alterations or additions it was advisable to make in the design of the works. At that time these provided for decanting the water from the higher to the lower storage-reservoir on the Elan, roughly straining it at the inlet to the aqueduct, screening it at the outlet end of the Foel Tunnel, and filtering it below the service-reservoirs near Birmingham. It had been clear that something more must be done. Accordingly, the draw-off arrangements at the intake-tower (then not absolutely settled) had been so modified as to give very delicate control of the final decantation. Further it had been decided to put in a range of filter-beds preceded by fine-gauze upward screens, competent, it was hoped, to arrest the matters which went to form the slimy deposit referred to by Professor Campbell Brown. He wished to express his acknowledgments of the courtesy and cordial co-operation of Professor Brown and his colleagues in the Liverpool investigations. Mr. Mansergh.

Mr. GEORGE F. DEACON remarked that it was important to bear in mind the distinction between the different kinds of obstruction which reduced the flow of water in iron mains. The 42-inch Vyrnwy main was put into use about 13 years ago: it had been designed to pass a certain quantity of water, and there could be no doubt as to the correctness of the calculations. An allowance of 25 per cent. had been made for nodular incrustation, which it was well known would occur in the course of 15 to 20 years. Such incrustations were familiar to every one who had had to lay iron mains in the north of England, or for almost any soft waters, and certainly for waters that had an acid reaction. But the obstruction which had given rise to Professor Campbell Brown's Paper was quite a different thing. Probably nothing would have been heard of the matter had it not been that the Vyrnwy main, which was about 68 miles long, was divided by the Oswestry filter-beds, at about one-quarter of its length from Lake Vyrnwy. Very soon after taking it into use, the portion between the lake and the filter-beds had begun to diminish in capacity, while the portion between the filter-beds and Prescot, where the principal service-reservoirs for Liverpool were, had remained practically unchanged. Although the delivery of no portion fell below that for which the Mr. Deacon.

Mr. Deacon. main was calculated, the difference in the delivery of thes portions—then about 25 per cent. higher below the filters above them—had naturally attracted attention, and the Liv Corporation had asked him to look into the matter. H found what he had seen in many other mains, namely, a coating of the interior, and, lying in the bottom of the p material which looked very much like coffee-grounds wher through clear water in a white vessel. That was the material which Professor Brown had described, the slime the live material. The slime and the little pellicles of material in the bottom combined, had reduced the capacity main above the filter-beds by more than 20 per cent. The did its work of obstruction while adhering to the sides pipe in the manner described by Professor Brown; but the pellicles, which were heavier than water, produced a spe harmful resistance in a totally different way, which was g aggravated by the fact that in the main between Lake Vy and the Oswestry filter-beds, there were about twenty u portions with an aggregate vertical height of about 2,300 fee the gradient had been everywhere downward the pellicles have been constantly washed out to the next reservoir; but was, the water was constantly engaged in the work of Sisy the pellicles being just light enough to rise with the max velocities of flow, and just sufficiently heavy to fall back again momentary lull that followed. Like myriads of little marbles, pellicles acted as a most efficient brake, and were largely respo for the increased resistance to the flow of water. Chemist bacteriologists had been called in, and Professor Brown had s once that the deposit was not peat, and had begun to investig In the meantime, Mr. Deacon had devised a mechanical brusl avoided the scraper first introduced by the late Mr. W. Froud constructed by Mr. Appold, which scraped the interior in s manner that any projecting portions of the nodular incrust were carried away. It was unnecessary for him to dwell up details of the brush apparatus, which he had described elsew Substantially, it consisted of two co-axial drums, the periph each drum consisting of bristles of whalebone, arranged spira such a manner that the hinder brush acted like the guides turbine, and the forward brush like the vanes of a turbine. water could not flow in any quantity without passing throug guides, and so actuating the vanes of the forward brush; th

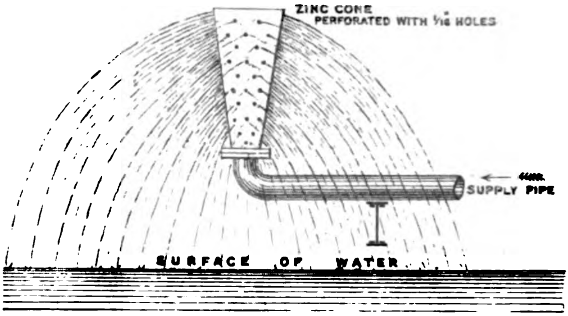
[1] Proceedings Institution Mechanical Engineers, 1899, p. 502.

drums revolved in opposite directions. He had not felt sure Mr. Deacon. that the brush would be a success on the first trial without some adjustment. It disappeared, and it was thought it must have stuck somewhere, because it could not be found at the next point at which there was ingress to the main. But, as a matter of fact, it was found within ½ an hour, several miles away; it had done its work for that portion, and had washed out practically the whole of the material, which travelled with the water a little ahead of the brush. The use of the brush had continued, and had proved a complete success, but of course its effect had been only temporary. The growth of slime and the accumulation of dead pellicles had been resumed, and the brushing had had to be repeated. Happily the brush did no harm to the interior of the pipe; the coating of asphalt was left intact, and the nodular incrustations, such as there were, had not been removed. Indeed, at that time, nodular incrustations had scarcely begun to form. It was very satisfactory to hear from Professor Brown that the slime rarely, if ever, formed in anything but acid water; but unfortunately the nodular incrustations formed in both acid and alkaline waters, though much more readily in the former. In the south of England, for example, the chalk waters showed scarcely any nodular incrustations, which he believed was principally due to the fact that carbonate of lime was deposited on the inner surface of the pipe before they had a chance of forming. He must admit that he rather agreed with Professor Brown that the use of the hydraulic scraper, as distinguished from the rotating brush, was not desirable if it could possibly be avoided. He knew many places in which it was used, and the pipes were being gradually worn away. In some places it was used every year, and in other places every two years. The process interfered with the supply; and in many cases it would be better to let the incrustations grow and form, as they certainly did, a complete protection to the iron of a main with reduced but constant delivery. This would often involve the laying of a duplicate main, which in the long run was often found to be the more economical course.

Mr. R. St. George Moore endorsed Messrs. Chadwick and Blount's Mr. Moore. remarks as to the aeration of water in thin streams. He had been using that method on West Hampshire water for the last 6 years. The intake in the early stages had been below a water-wheel, and he had found that when the water-wheel was working, the monthly analyses were better than when the wheel was at rest. He had set to work to find a substitute for the aerating action of the water-wheel, and had devised a series of zinc cones perforated with

Mr. Moore. not larger than $\frac{1}{16}$-inch in diameter (*Fig. 1*), through which the whole of the water was delivered on the filter-beds in a fine spray;

Fig. 1.



and he found that the analyses were even better than they had been when the water-wheel was at work.

Mr. Hunter. Mr. WALTER HUNTER considered that Professor Brown's Paper showed how necessary it was to treat all waters by filtration, whether they came from mountain surfaces or from rivers; and this fact would probably have a wide application in dealing with the future needs of the Metropolis. In regard to incrustations in pipes, he recollected having a pipe brought up from Swanage some years ago, where the water was very chalky, which was really more filled with deposit than the pipe shown by Mr. Mansergh. In fact there was not more than one-fourth of the cross-sectional area of the pipe available for the conveyance of water. With regard to the water-supply received from the Thames, 2 or 3 years ago he had cut out a 24-inch pipe in Hyde Park which had been in since 1819, and was in a perfect condition. A few nodules were found inside, but practically the capacity of the pipe had not been interfered with in the least, and the pipe was in as good condition as when put in. Of course the pipe had always conveyed filtered water, and possibly its excellent state after so many years might be partly due to this fact.

Mr. CHARLES HAWKSLEY, Past-President, mentioned that the town of Whitehaven, which was supplied with very soft water from a lake, had its pipes laid many years before Dr. Angus Smith's process of coating was introduced, and the pipes were laid without any coating. In the course of time—probably not more than 20 years—many of the 3-inch pipes had become almost completely filled
[illegible]. From what Professor Campbell Brown said in his
[illegible]o from the experience on the Vyrnwy line of pipe

it seemed advisable to put the filter-beds, where possible, at the commencement rather than at the termination of a pipe-line; but where that had not been done it certainly appeared desirable to make use of the existing pipe by repeated scrapings, at all events until it had become worn so thin that it would no longer serve its purpose, when, of course, it must be replaced by a new pipe. Mr. Hawksley.

Mr. R. E. ELLIS had had some experience in the waterworks of Madras, and had seen limpets formed on such a scale as to render it barely possible to see through a 7-inch pipe. The deposit was not of a calcareous nature; it was of the limpet form, and the smell from it when it was removed was very offensive. The curious thing was that though the same water was eventually pumped out in the form of sewage through an iron main, there was no deposit of any sort in that main, which was as clean then as on the day it was put in. Mr. Ellis.

Sir GUILFORD L. MOLESWORTH, K.C.I.E., Vice-President, had inspected the waterworks at Singapore, and could corroborate the statement as to the condition of the water there. It was of a dark yellow colour, and smelt abominably. It was very satisfactory to find that the arrangements which had been made had the result of purifying that water. Sir Guilford Molesworth.

Mr. JOSEPH FRANCIS remarked that there was one matter in which he had taken some interest in connection with the first Paper, namely, the protection of the inside of pipes by Dr. Angus Smith's process. Pipe-founders usually asserted that the coating would be found to be perfectly satisfactory, but unfortunately it hardly ever was so. Many of the pipes laid some years ago, soon after the first adoption of the process, were found to be in a perfectly satisfactory condition, but his experience was that, as now conducted, the process might be called a failure. Whether that was due to want of care in carrying it out, or to want of knowledge and attention in providing the proper ingredients in their right proportions, he did not know; but, as a matter of fact, pipes from all the large British ironfounders had serious defects in the coating. He had been told recently that in America a method of coating was adopted in which a solution of rubber was used; and it would be interesting to hear exactly how that was carried out, and with what success. Mr. Francis.

Mr. E. H. G. BREWSTER considered that a great deal depended on the quality of the iron of which the pipes were made. Papers[1] Mr. Brewster.

[1] Minutes of Proceedings Inst. C.E., vol. i. (1840) p. 70, and vol. ii. (1843) p. 171.

Mr. Brewster. by Mr. Mallet, read before the Institution many years ago, gave particulars showing the necessity of paying attention to the composition of the cast iron used for structures exposed to water; and also pointed out that certain compositions decayed very rapidly in water and became soft. That was well known to many engineers, but not to all; and it was just possible that in some cases where there had been failures in the pipes the composition of the cast iron had not been of a suitable character. As an illustration he might say that quite recently he had examined two small cast-iron tanks, made by the same maker though probably at different periods, containing water of the Southwark and Vauxhall Water Company. The water in both tanks had been in constant agitation, and the tanks were continually being filled and discharged. One tank he had found to be full of large nodules similar to those which had been described, and the metal inside the tank was very soft. The other tank was practically unaffected; it was merely slightly rusty. From what he had heard, and from his own observations, he thought the composition of the pipes themselves would have a good deal to do with the growth of the nodules.

Prof. Brown. Professor Campbell Brown, in reply, remarked that although Mr. Mansergh apparently held a different opinion from himself in regard to the wisdom of scraping, there did not seem to be really much difference between them. If he were advising an engineer, he would undoubtedly—if it were in the engineer's own interests and in the interests of engineers as a body—advise him to scrape, because in that way a rather larger flow of water would be obtained. But if he were advising a Corporation, he did not think he would give such advice; because the use of the scraper would cause the water-pipe to have a shorter life, and it was just a question whether the advantage of having a little larger flow of water for a certain period was cheaper in the end than having a slightly less flow for some longer period. Naturally, an engineer was willing to put in pipes as often as they were worn out. The deposits of lime came, of course, from the water, and could be scraped out without injury to the pipe. But it would be found that the metal of the pipe he himself exhibited had been changed, so that on the outside it would spoil the edge of a knife, while on the inside the knife would cut it. The reason why the life of pipes was shortened by scraping was that the incrustation protected them, somewhat in the same way as a layer of pitch or india-rubber did. By scraping it away, a fresh surface was exposed to the action of the oxidising water. The material of th

incrustation was supplied from the pipe itself and not from the water. With regard to the question of peat, he had attacked the problem patiently and slowly, applying, as far as possible, the principles of inductive reasoning. He had no preconceived theory. Some of his engineering friends had said the deposit was peat, but on examination he had found that it was not: it was connected with peat, however. The peaty waters getting iron from iron springs, the acids from peat helped to dissolve and keep in solution that iron, and formed a compound of carbonaceous acid with the iron, which flowed along the pipe. Wherever he happened to have found peat particles in the water there was no deposit of slime. He had found undoubted peat in a sample of water taken from a tap in Glasgow, and there was no slime in the Glasgow pipes. The "limpets" were often apparently symmetrically placed, and that had been attributed to microbes, to electricity, and to various other causes. If a solution of Epsom salts was taken and a little gum put into it, and it was then spread over a sheet of glass and allowed to crystallize, the crystallization would start at uncertain points. If it were touched with a piece of glass rod it would start crystallizing at each of the places touched; if there was a little dirt on the place it would begin there, and if a fly brushed it with its wings it would begin there. That was neither electricity nor microbes. It was a process of crystallization; and he took it the formation of the incrustations was of a similar kind. Many things would start it—roughness in the iron pipe, a pin-hole in the pitch, and so on. The object of the coating of pitch was merely to prevent the water from getting at the pipe, and if the coating was imperfect the process failed. If the india-rubber stuck to the pipe it would not fail. The pitch failed because perhaps it was not of the proper composition, and was not properly applied. He thought Mr. Joseph Parry had solved the difficulty of putting on pitch properly, and 50 years hence the pipes laid down by him would be found as good as they were to-day. The Angus Smith coating applied by Angus Smith was satisfactory; but, put on empirically by contractors who only knew the words in the contract, it would not be satisfactory. The incrustation was a very small matter. The diminution of the sectional area of the pipe was relatively large in a small pipe, which might be completely blocked; but in a large pipe—4 feet or more in diameter—it was not of great importance. The Rivington pipe-line, laid 50 years ago, had such a dense incrustation in it that the water could not get at the iron; and it was not increasing. To scrape that off would be a mistake, because it would simply Prof. Brown.

Prof. Brown. start the oxidation again. The choking of the Vyrnwy pipes was not due to such incrustations. Limpets were dotted over them, but did not seriously impede the flow, the impediment being due to something else. What that was he had discovered by slow investigation, and he had described the process of growth of the deposit in his Paper. His investigations touched upon a matter of wider interest, a question connected with the philosophy of life. If Winogradsky's views had been correct, there would have been an example of living organisms deriving their energy from the oxidation of mere mineral matter. These views had been proved incorrect; and although certain mineral matters were necessary ingredients of food, an example was still wanting of a living thing which did not derive its vital energy from the consumption of some carbon compound.

Mr. Blount. Mr. Blount, in reply, expressed his obligation to Mr. St. George Moore for the description he had given of his experience. Evidently that plan was efficacious; and he believed that if Mr. Moore adopted the method of distributing described in the Paper, the advantage he had noticed would be enhanced. The trouble at Singapore had been quite as serious as Sir Guilford Molesworth had stated. Mr. Tomlinson had attacked the problem differently from the method adopted by Mr. Chadwick and himself, but on the same principle, and with equal success. With regard to the remarks of Professor Campbell Brown, the quantity of iron used was 20 lbs. per million gallons, but with a better method of aerating the water in the revolver, this quantity was now increased. The object in view was, in great measure, the oxidation of the impurities in the water, and for this purpose the complete aeration of the water was desirable, if not essential. The only reason for using a fairly large orifice was to avoid accidental stoppage; even when this somewhat large orifice was employed, the loss of head was not serious, and, on practical grounds, the larger size was preferable. Whether a large or a small orifice was adopted, the aeration was sensibly perfect. The action of the iron was, in some degree, due to the precipitation of ferric hydroxide derived from the oxidation of a ferrous salt, but more important was the action of ferrous hydroxide as a carrier of oxygen. The proof of this lay in the fact that the organic impurities were not merely precipitated but oxidised, a result not attained by aeration alone.

The President remarked that, while he knew nothing about deposits in water-pipes, he knew a good deal about corrosion and fouling on iron ships; and he entirely agreed with Professor B[illegible] remarks as to the serious obstruction presented by a

The President.

growth of the kind described in his Paper on a surface past which water had to flow. It was extraordinary what an enormous increase in resistance might be found when the bottom of a ship was not apparently very dirty. Not long ago, in a vessel for the design of which he had been responsible, there had been a difficulty in getting the intended speed; and although he had ceased to be in active work, he had analyzed the matter and had come to the conclusion that the cause was a dirty bottom. He had been told that was impossible; but he had urged those who succeeded him to make an investigation; and he might say that when the bottom had been scraped and painted, the same speed had been obtained with 5,700 I.HP. less. It seemed to be only a little detail, but it meant a good deal to the performance of the ship, as well as to the credit and the comfort of the designer. That result had been due not to absolute dirtiness of bottom, but simply to a roughness of surface, which had at first been looked upon as comparatively unimportant. In such a case an apparently trifling growth might have marked effects.

Correspondence.

Mr. Appleyard.

Mr. Rollo Appleyard remarked that engineers had hitherto handled in too empirical a manner the problem dealt with by Professor Campbell Brown. It would be interesting to have Professor Brown's opinion on the important question of the extent of the corrosive action corresponding to each class of deposit, and as to what connection, if any, existed between corrosion and deposit. If slimy growths proved to have a corrosive effect, the slime in surface water and on water surfaces would be of importance in considering the corrosion usually regarded as being due to simple oxidation at the wind-and-water line of ships, tanks, and all partially submerged iron structures. In regard to preservatives there appeared to be only one point upon which there was universal agreement, namely, that the iron must be freed from rust, scale, grease, and moisture, before applying the protective coating. Although this cardinal principle was well known, it was far too frequently neglected. The methods of preparing the surfaces of iron structures for painting were altogether crude, and the preservative compound was often blamed for the fault of the person who applied it; hence, also, the anomalous results obtained with th

Mr. Appleyard. same compound. With regard to india-rubber as a preservati iron pipes, it was somewhat difficult to see how this subs could be used except as a solution in naphtha or its equiv A solution of india-rubber in naphtha was not very stable, es ally in contact with metals; the question of durability v therefore have to be studied before adopting this method. I not appear to be generally known that ebonite could be vulca upon iron, forming complete protection and, of course, insul the iron. This method might be useful in special cases v complete protection was required, and where expense was n prime importance.

Mr. Bruce. Mr. A. FAIRLIE BRUCE desired to offer a few observations i light of his experience as Water Engineer to the Bo Municipality. The water-supply of Bombay was derived three artificial lakes: Tansa lake[1] situated on the mainland distance of about 57 miles, and Vehar and Tulsi lakes in the I of Salsette, about 13 miles and 16 miles respectively from the The gathering-ground of the former was covered chiefly witl jungle, but had some small areas of paddy-field at its no extremity, and a few small villages scattered over it, at dis of 1 mile to 10 miles from the lake. The two latter lakes completely surrounded by a thick mixed jungle, and throu both areas there was a rank growth of grass during the mo frequently burnt by jungle-fires in the dry weather. Owi the great area and depth of the Tansa lake, respectively 5½ s miles and about 100 feet at the maximum, the sedimentatio much more perfect than in the other lakes, and the quality water was consequently much superior. When the reservo originally constructed, its area was only imperfectly clea timber, and he had taken advantage of the unusually low le the lake in the famine year of 1899 to saw off at the wate and remove the bulk of the trees, whereby a marked diminu the growth of algæ had been effected, with a correspo improvement in the quality of the water. The water of the and Vehar lakes contained large quantities of algæ, partic after the close of the monsoon and again in the hot weather the end of March until the burst of the monsoon in the mi June. There was also a large quantity of weed at the upper the Vehar lake, which, though it might have a somewhat prej effect on the quality of the water when it died, probably h

[1] "The Tansa Works for the Water-Supply of Bombay," by W. J. B. Minutes of Proceedings Inst. C.E., vol. cxv. p. 12.

compensating property of absorbing a considerable quantity of algæ, which was probably consumed by the low forms of insect life of which the weed formed the habitat. The Tansa water was conveyed to Bombay partly by means of a built aqueduct and partly in 48-inch pipes; that of the Vehar lake in a 32-inch and a 24-inch main, and the water from the Tulsi lake in a 24-inch main. None of these waters—varying in hardness between 1° and 2°—had any pronounced action on cast iron, only forming a thin scale of rust after the disappearance of the protective coating; and the only cases in which partial obstruction had occurred had been in a number of 3-inch mains laid about 45 years ago, which, though as a rule under nominal pressure, had no appreciable flow through them for 16 hours or 17 hours a day, and in which the conditions were consequently favourable for the deposition of any silt contained in the water. The Tansa 48-inch pipes, which had been laid for about 12 years, only showed a reduction of discharge of about 6 per cent. to 7 per cent. below that calculated by Darcy's formula taking the value of ζ as 0·0034. The Vehar 24-inch main, which was about 18 years old, showed a falling-off of about 18 per cent. The Tulsi 24-inch main, after being laid for 24 years, had lost 32 per cent., but passing a scraper through it 2 years ago had led to an increase of about 13 per cent. in its discharge; this gain had now, however, been lost again. The Vehar 32-inch main, which had been laid for 44 years, had lost about 34 per cent. of its carrying-capacity; it seemed to have reached this stage about 10 years ago, and certainly during the past 6 years, during which it has been under his charge, it had shown no further signs of internal deterioration. As far as his experience went, both in Bombay and elsewhere, he was of opinion that, in the case of large mains with a constant flow through them, the tendency was towards a low rate of diminution of discharge, which gradually accelerated as the coating disappeared, until it reached about 20 per cent., after which it again decreased until stability was attained at 30 per cent. to 40 per cent. below the rate of discharge when new. Where pipes had been laid in dry unpolluted soil there had been but little external corrosion in the Bombay pipes; but in view of a proposal to alter the line of the 32-inch main, which was at present laid along the embankment of the Great Indian Peninsular Railway for a distance of about 6 miles, it had recently been subjected to careful survey by a Government Commission of which he was a member, with a view to ascertain, among other things, to what extent it would be suitable for relaying. For a distance of about 2½ miles, where it was

Mr. Bruce.

Mr. Bruce. in damp soil containing about 20 per cent. of vegetable matt was found to have been subjected to a severe form of galv action, with the result that the metal had been eaten away wavy form and rendered so soft that it could be cut with a k the particles of iron being transferred to a crust of mingled and iron oxide, 2 inches to 3 inches thick, adhering firmly to exterior of the pipe. Several pipes on this section had burst thickness of sound metal left being reduced to less than $\frac{1}{8}$ and a large piece in each case being blown out of the botto the pipe. On the other hand, in dry earth the metal had sh little or no signs of corrosion and the maximum depth to w oxidation had penetrated outside of the stretch of polluted was about $\frac{1}{4}$ inch. In another length of about 1 mile to the n of the railway, where the main had been subjected to the acti salt, the metal had peeled off in flakes $\frac{1}{16}$ to $\frac{1}{8}$ inch in thick due possibly to galvanic action, set up by the salt between la of metal of slightly different composition, leading to the fo tion of oxide between them, which gradually split them asu While the Tansa water had always proved satisfactory, and Vehar water generally so, that from Tulsi had always g more or less trouble during the period of warm weather, after the cessation of the rains, and in the three montl hot weather which preceded them. A rise of a few degre temperature had a marked effect, and the improvement due day or two of cloudy weather was often very notice It having been observed that the water deteriorated to a appreciable degree in transit from the lake to the filter Malabar Hill, it had been determined to take samples from cocks along the line. For the first 3 miles, where the main protected by jungle from the effects of the sun's rays, no a ciable difference had been observable between the samples d from the pipes and the water in the lake; but for the rema of its length, where it was more or less exposed, each succe sample had shown a steady deterioration, an increase in the ammonia, and a gradually deepening yellow shade, accomp by a faint sickly odour. When scraped, the pipe had been f to be coated with the black slime alluded to by Professor Br containing sulphide of iron, about 1,800 colonies of cocci per centimetre, and a variety of low forms of vegetable life. It been proposed to cover this portion of the main with 2 feet of in order to protect it from the sun, but the sanction of the poration has not yet been accorded to the necessary expendi Neither the Tansa nor the Vehar water had been found

affected in the manner above described, owing probably to the absence of iron from these waters, as well as to the smaller quantity, and, some difference in the quality of the vegetable matter contained in them. On arrival at Malabar Hill, the Tulsi water was passed through copper-wire screens having nineteen wires per lineal inch, and then through a settling-tank, and was afterwards filtered through sand filters of the ordinary type. Experience had shown that no advantage was gained by reducing the rate of filtration below 600 gallons per square yard, while the efficiency began to fall off after a rate of 700 gallons was attained. The rate adopted had therefore been between these two figures, with satisfactory results. The length of time during which a filter would work before the head necessary to pass water at the above rate exceeded 2 feet 6 inches, when the filter was cleaned, varied greatly with the season of the year, the minimum being about 12 days, the maximum 40 days, and the mean about 21 days. Before being again put in use, the filters were allowed to remain empty for at least 48 hours. The filtering-area has hitherto only been sufficient to filter about 55 per cent. of the water received, the balance being merely settled, and mixed with the filtered water in the clear-water reservoir. Soon after taking over charge of the works he had pointed out the impropriety of such a system, and had designed an extension by the addition of three new filters, to enable the whole supply from this source to be filtered. Considerable delay had occurred in obtaining sanction for the necessary expenditure, but the filters were now in course of construction, and it was hoped they would be in operation in another year. Professor Brown had done good service in calling attention to the defects of Dr. Angus Smith's solution, which afforded but a temporary protection to castings, and any improvement upon it would be welcomed by water-engineers. The proposal to dip pipes a second time at all events offered some hope of improvement, and appeared to be worth [illegible]ng. Mr. Bruce.

[illegible] was inclined to disagree with the view expressed by Messrs. Chadwick and Blount, that in order to get rid of the lower strata of impure water it was necessary to discharge them through an outlet at or near the bottom of the reservoir. It appeared to him that a reservoir was precisely similar to a large pool in the course of a river, through which there was a steady flow down to the very bottom. As water flowed in from tributary streams and passed over the waste-weir, the current, though it might be imperceptible, must extend to the bottom layers, which rose and passed over the weir. Messrs. Chadwick and Blount also lost sight of the ac[illegible]

Mr. Bruce.

ANALYSES OF BOMBAY WATER.

No.	Source of Sample.	Grains per Gallon.		Parts per Million.		Remarks.
		Total Solids.	Chlorine	Free Ammonia.	Albuminoid Ammonia.	
				October, 1902.		
	Vehar Water.					
1	Vehar Lake.	7	1·1	Trace	0·194	Large numbers of a present; fairly c and bright. Nitrites—Nil.
2	Inlet-channel to the Bhandarwada Reservoirs (Unfiltered).	7	1·1	Nil	0·186	Large numbers of a present, other clear, bright and from sediment. Nitrites—Nil.
3	Filtered channel of Filter No. 2.	5	1·1	Nil	0·056	Clear and bri (Rate of filtration gallons per sq yard per 24 hours
	Tansa Water.					
1	Tansa Lake.	8	0·7	0·04	0·052	Fairly clear and bri Nitrites—Nil.
2	48-inch main at Chinchpokli.	7	0·65	Nil	0·032	Clear and bright. very pure water. Nitrites—Nil.
	Tulsi Water.					
1	Tulsi Lake.	9	1·15	Nil	0·174	Slightly coloured. algæ present. Nitrites—Nil.
2	Receiving well at Malabar Hill Reservoirs. (Unfiltered.)	10	1·15	Nil	0·108	Faint brown tinge. algæ present. Nitrites—Nil.
3	Filtered channel of Filter No. 4.	8	1·15	0·112	0·068	Fairly clear and bri (Rate of filtra 633 gallons per sq yard per 24 hours
				January, 1903.		
	Tulsi Water.					
1	Tulsi Lake, Jan. 26.	7	1·1	nil	0·160	Faint brownish ti fine particles of v table débris pres but no algæ.
2	Receiving well at Malabar Hill. Jan. 13. (Unfiltered.)	7	1·0	trace	0·196	Faint brownish tin no smell; no alg Nitrites and Nitr absent.
3	Filtered water channel of Filter No. 1. Jan. 13. Filter working since Jan. 3.	6	1·0	nil	0·06	Clear and bright; sediment. (Rate filtration 627 gal per square yard 24 hours.)
	Vehar Water.					
1	Vehar Lake, Jan. 26.	7	1·0	nil	0·244	Slightly colou and contained la numbers of algæ. Nitrites and Nitr absent.

ANALYSES OF BOMBAY WATER—*continued*.

Mr. Bruce.

No.	Source of Sample.	Grains per Gallon. Total Solids.	Grains per Gallon. Chlorine.	Parts per Million. Free Ammonia.	Parts per Million. Albuminoid Ammonia.	Remarks.
			January, 1903 (*cont.*)			
	Vehar Water (*cont.*).					
2	Inlet-channel to the Bhandarwada Reservoirs. Jan. 16. (Unfiltered.)	7	1·0	nil	0·172	Fairly clear and bright very few algæ. Nitrites and Nitrates absent.
3	Filtered-water channel of Filter No. 5. Filter had been at work for 13 days.	6	1·0	nil	0·078	Clear and bright. (Rate of filtration 463 gallons per square yard per 24 hours.)
	Tansa Water.					
1	Tansa Lake. Jan. 16.	6	0·65	0·034	0·104	Fairly clear and bright; a few algæ present.
2	48-inch main at Chinchpokli. Jan. 23.	6	0·65	nil	0·076	Fairly clear and bright. A few fragments of vegetable débris, but no algæ. Nitrites and Nitrates absent.
			May, 1903.			
	Tulsi Water.					
1	Tulsi Lake, May 13.	7·0	1·2	0·024	0·298	Many algæ present. Iron 0·001 parts per 100,000.
2	Outlet-tower at Tulsi Lake, May 13.	7·5	1·2	Trace	0·402	Algæ very numerous. No yellow colour. Iron 0·005 parts per 100,000.
3	Receiving well at Malabar Hill, May 12. (Unfiltered.)	8·5	1·2	0·176	0·196	Deep yellow colour. Very few algæ. Iron 0·14 parts per 100,000.
4	Filter No. 1, May 12. (Filtered.)	7·0	1·2	Trace	0·132	Fairly clear and bright. No yellow colour or sediment. Iron 0·03 parts per 100,000.
	Vehar Water.					
1	Vehar Lake, May 14.	8·0	1·2	Trace	0·522	Slightly coloured. Algæ abundant.
2	Outlet-tower at Vehar Lake, May 14.	8·0	1·2	0·04	0·520	
3	Entrance-channel to Bhandarwada Reservoir, May 15. (Unfiltered.)	8·0	1·2	Trace	0·160	Some algæ present.
4	Clear-water channel of filter. May 15.	7·0	1·2	Trace	0·058	Clear and bright. No sediment. (Rate of filtration 450 gals. per sq. yard.)
	Tansa Water.					
1	Tansa Lake, May 16.	8·0	0·7	0·056	0·096	Fairly clear and bright. A few algæ present.
2	48-inch main at Chinchpokli. May 26.	8·0	0·7	Nil	0·066	Clear and bright. No algæ.

Mr. Bruce. of wind, which almost invariably accompanied heavy rain, a which caused a turn over in the water of a lake or reservo It was noticeable that the Bombay water usually showed sig of deterioration for a short period immediately after the fi burst of the monsoon, which might be attributable to this cau Some typical analyses of the Bombay water-supply at differe seasons of the year, namely, in October, in January, and in Ma were given on pp. 58 and 59, which might be of interest.

Mr. Campbell. Mr. A. H. CAMPBELL pointed out that, while Messrs. Chadwi and Blount's Paper referred mainly to tropical conditions, the conditions had their counterpart at home, where the standard of sa tation was keener than abroad. The action of large communit in going far afield for a suitable source of water-supply, while secured a gathering-ground removed from the pollutions incide to inhabited areas, did not deliver the water-engineer from troub of an alternative kind—for instance, that due to the decay of veg tation; and if thereby organic impurity was not introduced in the water to an injurious degree, probably discoloration occurr and the water had a brownish, dirty-yellow hue, which, if n hurtful to the body, was certainly offensive to the eye. Wat obtained from moorlands where peat abounded was specially lial to this discoloration, as was also water derived from land of marly description. It had been his duty about 10 years ago, engineer of the waterworks of a town in the midlands, to appe the local animus arising from the turbidity of the town wat supply after rainfall. The cause of this turbidity was probab twofold. First, the soil of the gathering-ground was a de red coloured marl; secondly, there was a good deal of woodla upon the catchment-area. During the fall of the year, and at oth flood times, very turbid water was obtained. Moreover, as t storage-capacity was limited, and the filtering-area was small, t conditions were probably as unfavourable as could be. The wat supplied under such conditions was neither palatable nor inviting appearance. The storage-reservoir had been nearly exhausted by long period of drought, and there was only about 10 days' availal supply in the reservoir when rain came to relieve the extremity. had therefore become necessary to take in the water as it came do in flood, trusting to the sand filters to reduce, if not to remove, t impurities. But the action of sand filters of ordinary compositi was helpless to remedy the defect in the purity and appearance the water under such conditions. Of course, increased storage a larger filtering-area, service-reservoir equipments, etc., would ha assisted, but time would have been needed for the application

those measures. They would have been ultimate palliatives rather than the immediate correctives which the case urgently demanded. The plan adopted had therefore been to uncover the sand-bed of the filter to a depth of about 15 inches, and to embed at that depth in the filtering media a 6-inch layer of what was then called "porous carbon," but which was really a carbonaceous powder, granulated to about $\frac{1}{8}$ to $\frac{1}{4}$ inch size. The top layer of sand was then replaced, and the water was turned on to the filter as before. The change at once wrought by the introduction of this material was very marked, the turbidity being quite removed. The material had remained ever since in the filters, and continued to do the same good service. Another instance of discoloration was the Moorfoot supply to Edinburgh, which was often discoloured and turbid after rainfall, due to a peaty gathering-ground, inadequate storage, and insufficient filtering-area. Again, the submergence of large valleys, containing perhaps hamlets, woodlands and large tracts of rich arable land, must necessarily involve the presence of decomposed organic matter in the water, and necessitate exceptional methods of treatment. Waterworks engineers had not only to satisfy chemical and biological requirements, but must pay attention to the appearance of the water for drinking purposes. The practice of the engineers of the Metropolitan Water Companies of testing for colour in a tube about 2 feet in length was good; and it was highly creditable to the management of the filters of those companies that the waters from some at least of their sources of supply could be clarified so as to pass satisfactorily such tests. With regard to the application of the theory of aeration to the purification of sewage, aeration of sewage, or of any impure water, by exposing it in fine drops to the atmosphere, was becoming very general in sewage-works, and devices for the purpose were numerous. He had recently had practical proof of the efficacy of passing effluent sewage, after precipitation of the sludge, over a series of weirs in a thin, filmy stream; and for the purpose of sewage-purification there was no doubt that repeated aeration of the liquid was of the highest value. The clarification and purification effected at the sewage-works in question was demonstrated by the support of fish life in a small vessel of effluent, unchanged for weeks. Mr. Campbell.

Mr. J. E. Cornish observed that Professor Campbell Brown's Paper was evidently the result of minute observation on an important subject which had probably never before been so clearly dealt with. In determining the proper diameter of pipes for the distribution of water, the question treated in the Paper, though of the greatest Mr. Cornish.

Mr. Cornish. importance and one requiring a special study for every qualit water, was too often neglected: with the result that mains frequently to be replaced at great cost before they were half w out. He was pleased to find that the Author did not approv the removal of incrustation by scraping. There was at pres too great a tendency to rely on this process, and cases had o under his observation in which damage had resulted f its use. In several cases known to him the results of depo had coincided very closely with those described in the Pa He had had to remove, 38 years ago, a considerable quan of 8-inch lead pipe in connection with the Rouen waterworks, to have been laid more than 400 years. The water it delive which flowed from a spring in the chalk, was beautifully clear bright, and contained a small amount of sulphate of lime. inner surface of the pipe was very evenly coated to a thick of about $\frac{3}{8}$ inch with an exceedingly hard deposit of fa smooth surface, which did not obstruct the flow of w to a much greater extent than the proportionate reductio the sectional area. The Author was quite right in laying g stress on the advantage of a good coating for pipes. water of the Nile had a considerable effect on uncoated cast i Only a week previously he had had a piece cut out of a 26-i main which had been in constant work for 43 years. The coa was still perfectly good, and the iron was hardly affected on internal surface, but there was a certain amount of rough dep and in a piece about 6 feet long there were three mussel-sh each over 4 inches in diameter, firmly adhering to the inner surf the pipe was used for the delivery of unfiltered water from a pu and the water passing through it had always been stra beforehand. He hoped the Author might continue his useful interesting observations, as the subject was by no means exhau

Having had many years' experience in connection with the fi tion of water from the Nile, he had read with interest the met adopted by Messrs. Chadwick and Blount in dealing with w highly charged with vegetable matter. On the one hand, t were probably few rivers whose water was more affected vegetable matter than were the upper waters of the Nile; on other hand, there was no other river in which the water pollution was so much exposed to the beneficial rays of the Still, at certain seasons of the year, even at Alexandria, the w has a decidedly greenish tint from this cause, and, if stagnant liable to rapid deterioration. The difficulty of dealing with water, as it arrived at Alexandria, was considerably increase

Mr. Cornish. its being heavily charged with clay in such fine particles that ordinary sedimentation had but little effect, and filters rapidly became choked. During the last 9 years many experiments had been made in order to determine the best manner of dealing with this water. About 3 years ago, Professor Bitter, who was conducting the experiments then, had come to the conclusion that, of the many systems which had been tried, the best results were given by slow sand-filtration after the water had been clarified by mixture with a solution of permanganate of potash, and passed through large sedimentation tanks of a special form. Designs had been prepared and the works were to have been begun in 1902, when it had been suggested that another trial should be made of a system of rapid filtration by mechanical means, after sedimentation with a solution of sulphate of alumina. Experiments continued for several months had proved that (1) with a speed of filtration fifty times as rapid as that of the slow sand filters, a better bacterial result was produced, together with a perfectly clear filtrate; (2) whereas, with the slow sand filters, a staff of some fifty persons would be required for cleaning the filters, with the rapid system the whole work was done by mechanical means; (3) with the slow sand filters, the film forming on the sand, and containing much vegetable matter, might remain stationary several weeks at a time, whereas with the mechanical filters, it was all washed away twice during the day of 24 hours; (4) the cost of the mechanical system was less than that of the slow sand filters. The result of these experiments, made on a quantity of 120 cubic metres (26,400 gallons) per day, had been that the rapid mechanical system had been adopted, and was now being carried out with a plant capable of filtering 36,000 cubic metres (7,918,000 gallons) per day. In these experiments, the most delicate tests had failed to discover any trace of the sulphate of alumina in the filtered water. He considered that the system described would deal with the waters referred to by Messrs. Chadwick and Blount in a more satisfactory way than the methods proposed by them.

Mr. Friend. Mr. A. P. Friend contributed some notes on the composition of Nile water, and the system of treatment which had been proposed for Cairo. As the Cairo waterworks had obtained a very pure water from wells, and in future would not require filters, it was unnecessary to study the question further; but the notes might be of interest. Every year about the end of June there arrived at Cairo what was called the "green water," which greatly interfered with the filtration. The quantity varied considerably in different years. It lasted

Mr. Friend. however, only 10 to 15 days, so that it had not been considered ne
sary to go to great expense in trying to deal with the diffic
In a bad year great expense was even now incurred in scraping
filters and renewing the sand. This "green water" contained a l
organic matter only in suspension, but a large quantity in solu
The actual cause of the stoppage of filtration was the forma
under the influence of the sun, of a highly nutritive mediu
muddy and colloid layer composed of vegetable matter and fun
Settling and decantation was apparently of no assistance whate
The question of precipitation of this matter had been studied
both the filtered and the dirty water when green. Quicklime
been tried in sufficient quantity to precipitate all the carbona
lime in solution, and had been found to assist the filtra
slightly. Other processes had been tried subsequently. Almo
the methods had produced a precipitate, more or less chlorid
the undesirable constituents, by collecting the organic matte
suspension and solution. The water after such treatment
clear and easy to filter. The most satisfactory agent had
found to be sulphate of alumina or alumino-ferric, with ne
slaked lime. The consumption of this agent for, say, 25,000
metres (5,498,700 gallons) of water per day would be about 1
This process had been found to reduce in a marked degree the q
tity of organic matter in suspension and solution. The green
formed on the top of the water of the filters, and gave out a st
smell of stale fish. It increased very rapidly under exposu
the sun, and then sank and covered the sand, which in a
time became choked, and thereafter the filters ceased to work
it were possible to remove the slime from the sand, the que
would be much simplified; but this work, difficult in the day
was impossible at night. A certain amount had been don
scraping, skimming and continually changing the sand, bu
considerable expense, and with heavy loss of water. The wat
the filter had to be run away into the desert before cleaning
filters, and the calculated loss was at least 100,000 cubic m
(22 million gallons). The Nile water was at its worst when the
sumption was greatest, not only on account of the vegetable ma
but also on account of the enormous quantity of alluvial matt
suspension and solution. The cleaning of the filters greatly red
the area available, at a time when it could least be spared.
green-water trouble was luckily of short duration, but the all
matter continued for 4 or 5 months in diminishing quantity
with it a certain amount of vegetable matter. The filtratio
this water had been very thoroughly treated by Mr. A. Mu

Paris in a report written for the Water Company. Observations had been made on both Nile water direct from the river and water which had passed the filters; with the following results. The month of September, being the worst month of the year, had been chosen. Mr. Friend.

	Matter in Suspension. Grammes per Litre.
Water taken 6 September—	
1. In the middle of the Nile at a depth of 2 feet	2·295
2. At the intake of the Company	2·130
3. In the settling tanks	0·650
Water taken 18 September—	
4. In the middle of the Nile	1·945
5. At the intake to the settling-tanks	1·673
6. In the settling-tanks	0·370
Water taken from a filter—	
7. After the sand has been in 18 days	0·009
8. „ „ „ „ 74 „	0·006
9. In the clear water reservoir	0·012
Water taken in September from—	
10. Filter No. 5	0·005
11. „ „ 4	0·005
12. „ „ 3	0·010
13. „ „ 2	0·012 [1]
14. „ „ 1	0·013 [1]

The filtration had, therefore, eliminated nearly all the solids in suspension. The water was very slightly opalescent. This was difficult to get rid of, as the water was so slightly charged with carbonate of lime that the clay remained in suspension. If the water were less pure, the clay would be precipitated and the water would be clearer. It was impossible to eliminate the opalescence entirely even by filtering through paper. This good filtration was doubtless due to a large extent to the film of mud deposited on the filter, which was locally termed "limon." The thicker the layer of limon the better the filtration, as was shown by lines 7 and 8 in the foregoing Table. Besides the matter held in suspension, the Nile water contained also substances held in solution. In December this quantity amounted to 0·14 gramme per litre. This was very small, and showed the Nile to be very pure. The following were the various substances held in solution:—

	Grammes per Litre.
Calcium carbonate	0·086
Potassium nitrate	0·008
Magnesium chloride	0·003
Sodium „	0·009
Calcium sulphate	0·003
Silica and clay	0·031
Organic matter	0·003

[1] Filter No. 2 was not working well, and filter No. 1 had just had new sand put on it.

Mr. Friend. Little improvement from the point of view of purity could be expected from filtration. Any improvement desired would have to be made by the introduction of some foreign substance. The organic matter in river-water had two different origins, namely, the residue of animal life—which in the case of the Nile was very small, as there were no towns or villages to speak of above Cairo—and the residue of the vegetable matter, which in the ground formed acid bodies. All soils, even the most sterile, contained organic matter caused by the decomposition of vegetable matter. The water, in passing through the soil, collected a small quantity of the substance, which adhered to the limon already in the water, but was not very prejudicial. Many waters in America which, according to Humboldt, were pure and agreeable to the taste, contained as much as 0·025 gramme per litre. These organic matters existed in the Nile water before and after filtration equally, as they were soluble; and, however perfect the filtration, could not be susceptibly diminished. To eliminate them it would be necessary that the water should undergo oxidation; but this being a slow process, the passage of the water over the filters would not give the result desired, which would be obtained only by resting on the filters in presence of air. But to obtain this result it would be necessary that only a small quantity of water should be let into the filter at a time, so that the sand was not covered but only impregnated, thus enabling the air to circulate between the sand particles and produce oxidation. This would be out of the question, as the installation of such a system would require, for a quantity of 25,000 cubic metres per day, an area of 370 acres; and, moreover, it would be unnecessary. Oxidation could not take place in the submerged filters necessary to give the required output. The water passing through the filters arrived at a place where the medium was non-aerated, and, coming in contact with the limon containing organic matter, two effects might be produced:—

(1) A simple dissolution of the organic matter in the limon, which might be added to that already contained in the water. The following results, however, showed that the quantity did not increase during filtration:—

	Dissolved Organic Matter. Gramme per Litre.
Water taken at the pumping-station	0·0031
„ „ „ settling-tanks.	0·0030
„ „ „ filter working 18 days . .	0·0029
„ „ „ „ „ 74 „ . .	0·0031

(2) Conversion of nitrates and ammonia into nitrites by the

decomposition of the organic matter. The analysis showed that there was no appreciable quantity of nitrates. The quantities of nitric acid were:— Mr. Friend.

	Gramme per Litre.
Water taken at the pumping-station	0·0041
„ „ „ settling-tanks	0·0040
„ „ „ filter working 18 days . .	0·0040
„ „ „ „ „ 74 „ . .	0·0041

Therefore nitrates had not been decomposed, nor nitrites formed. Ammonia showed a slight increase, due without doubt to the organic matter contained in the limon through which the water had passed. The following observations had been made:—

	Ammonia. Gramme per Litre.
Water taken at the pumping-station	0·000015
„ „ „ settling-tanks	0·000020
„ „ „ filter after working 18 days .	0·000022
„ „ „ „ „ „ 74 „ .	0·000025

The sojourn of the water in the settling-tanks being stagnant, a slight increase took place, owing probably to want of aeration. The passage through the filters produced a more marked effect, and it was shown that the filter, which had been longest in work, gave the larger quantity of ammonia. This was not due to the sand but to limon, which covered and partly impregnated it. The renewal of the sand, and the scraping off of the limon, reduced the quantity considerably. The examination of the sands in the filtering media gave the following results:—

	Gramme per 100.
Sand taken from underneath the layer of natural sandy soil of the desert	0·011
Sand of the filters No. 5, taken at a depth of 10 centimetres	0·008
Sand of the same filter taken at the surface after 10 days of work	0·056

These figures showed that the top portion of the sand collected the organic matter, which did not impregnate all the sand; it was therefore sufficient to scrape off only a thin layer at the top in order to clean the filter. The lower sand retained its purity, or even became purified of part of its original nitrates by the water passing through it. The ammonia forming at the surface of the filtering media from want of aeration in this submerged apparatus would become more abundant the longer the water was in contact with the filtering media. It increased, therefore, with the depth of the filter-bed. Formation of ammonia would also be less active

Mr. Friend. the quicker the water passed through the filter. Retention of the water in the settling-tanks tended also to increase the ammo in proportion to the quantity of limon deposited. It was, therefo necessary to have the filters as thin as possible, only suffici thickness being allowed to retain the matter in suspensi to scrape off frequently the limon deposited; to renew the sa when the limon had penetrated it; to avoid allowing the water remain long in the settling-tanks, and to clean these frequen The water taken at the pumping-station and also at the settli tanks had contained more than 100 colonies of microbes. had been impossible to ascertain the exact number. The fi which had been working 18 days had given an average of colonies from seven samples, and the filter which had b working 74 days had given an average of 1·4 colonies. T showed that the filters eliminated a large majority of the micro averaging at least 97·5 per cent. and 98·5 per cent., which as satisfactory as could be expected. The reason why so go result was obtained with such rapid filtration was that the g majority of the microbes adhered to the particles of limon were deposited therewith on the surface of the filters. It w be noticed that the water of the filter in which the sand had been renewed for some time was the freer from microbes; fo already shown, the filtration was more thorough the longer sand had remained in the filter. The production of amm was directly in the opposite direction. Summing up the re of the observations it appeared (1) That the filtration which the object of eliminating the matter in suspension sufficie fulfilled the object desired by eliminating the greater pa the limon and a very large majority of the microbes. (2) ' the filters were powerless to change the chemical constitu of the water. (3) That the opalescence was inherent to chemical composition of the water, and indicated its pu (4) That the only inconvenience experienced in the filters the production of some traces of ammonia, which was la counterbalanced by the advantage of the elimination of microbes.

Dr. Kemna. Dr. Ad. Kemna, of Antwerp, observed that he had revie at some length Professor Campbell Brown's work when publ in the Report for 1901 by Mr. Joseph Parry on the Live water-supply. At the same time he had taken into conside some work by American practical scientists, namely, Mr. I

[1] *La Technologie Sanitaire*, 15 Aug. 1902, vol. viii. No. 2, p. 29.

D. Jackson and Mr. George C. Whipple, so that his review was a general article on growth in pipes. The interesting Paper by Messrs. Chadwick and Blount showed the powerful action of iron. Some experiments he had made in 1902 proved that the active part was the precipitated oxide. When a very yellow peaty water was agitated during a couple of minutes with ferric hydrate, and, after some subsidence run through a filter-paper, 80 per cent. of the organic matter was removed and the liquid was scarcely to be distinguished in colour from very pure distilled water, a column 1 metre long being of a deep blue. As destruction of the organic matter by oxidation was a slow process—the analytical method with potassium permanganate required at least 5 minutes' boiling—the very rapid action of ferric oxide could not be of a chemical nature. It was a purely physical one of absorption, like that of charcoal or of alumina. He had obtained the same results with precipitated alumina, where the fixation of the organic matter was clearly seen by the yellow coloration of the otherwise pure white precipitate. Carbonate of lime acted in the same way, but not so strongly. Aeration was now frequently resorted to in Germany for underground waters containing iron and sulphuretted hydrogen. The question had been discussed in 1902 at the Düsseldorf meeting of Gas and Water Engineers. The conflicting evidence could be explained, as he had shown elsewhere.[1] Dr. Kemna.

Mr. Sidney R. Lowcock expressed his appreciation of the scientific way in which Messrs. Chadwick and Blount had obtained their data in connection with the aeration of polluted waters. Although he did not think there was anything new in aeration of polluted waters subsequent to their treatment by the Anderson process or otherwise, he was not aware of any details of experiments other than Mr. Scott-Moncrieff's and his own, giving the actual amount of aeration required. Some years ago he had seen the works for the water-supply of Worcester, where the water was taken from the Severn, which, rising in the Welsh mountains, received *en route* the crude sewage of Stourport, Bewdley, Bridgenorth, Shrewsbury, and other places. This water was treated by the Anderson system, and subsequently flowed along a shallow channel having a perforated bed, through the perforations of which air was forced under pressure; but he had been unable to obtain any definite information as to the quantity of air so supplied per gallon of water. The result, however, was quite satisfactory. He had had experience in the treatment of water in the district Mr. Lowcock.

[1] Bulletin Société belge de Géologie, 1902, vol. xvi. p. 474.

Mr. Lowcock. adjoining Farnham, where the surface-waters were very similar t that mentioned by the Authors, being practically free from anim pollution, but highly charged with vegetable refuse, an becoming very offensive when stagnant. He was of opinion th this condition of the water here and elsewhere was largely du to the enormous number of pine-needles, both on the surface an in the subsoil. These not only decayed extremely slowly, bu contained secretions which were largely antiseptic and hindere and to some extent prevented, the decomposition of other dea vegetable matter in the vicinity, as well as that of the needl themselves. Whether the hard spines on the edges of the leave of the screw-pines (which, of course, were not of the genu *Pinus* at all) had any similar action, except in so far as the must decay very slowly, he did not know. These surface-wate were not used for dietetic purposes, and the nuisance arisin was obviated by cascading and by the promotion of circulatio that was, of course, by increased aeration. The subsoil-waters i the same district, which were used for drinking purposes, containe a considerable quantity of vegetable organic matter, and also iron dissolved out of the soil and held in solution by the vegetab acids. By delivering these waters into an open reservoir over th lip of a vertical bell-mouthed pipe, the lip being some distan above the top water-level, and promoting circulation in th reservoir by means of training-walls, sufficient aeration w obtained, and the iron was precipitated in the form of ferrugino jelly. The supernatant water was readily filtered throug ordinary sand filters and stored in a service-reservoir, the resu being quite satisfactory. This would appear to have some bearin on the formation of the slime described by Professor Brown, ar Mr. Lowcock would suggest that if the original stable conditi of the water containing iron held in solution by humus acids w broken down by preliminary aeration as the water left the reservoi the deposit of iron could be made to take place before th water entered the conduit and the action of the organisms i the conduit and pipes would be inhibited. Apparently, the actic of the organisms and the production of slime in the pipes was du to the water becoming more thoroughly aerated, and having i oxygen continually replenished, by its motion in passing along th conduit. The analysis of the slime, which showed no ferro oxide but a large amount of ferric oxide, seemed to support th view and to show that the slime was the result of comple biological oxidation. Filtration, according to Professor Brow statements, did not appear to be an absolute cure, and

thought this was because the filters were insufficiently aerated, and as a consequence, although they removed most of the organic matter and much of the iron held in acid combination with it, they did not break down the remainder by complete oxidation. In the treatment of tannery-refuse, when the whole of the waste waters were mixed together and consequently contained both animal and vegetable organic refuse, he had found that while chemical treatment alone gave an effluent which it was almost impossible to filter, if this effluent was thoroughly aerated and again allowed to precipitate, the second effluent could be readily filtered and a perfectly satisfactory result was obtained. With reference to Messrs. Chadwick and Blount's suggestions as to the aeration of sewage by passing it through perforated plates, his experience was that the endeavour to pass sewage or tank-effluent through small holes was most unsatisfactory and a continual source of trouble and expense. In addition to the physical difficulties, the biological difficulty would be that the organisms in the sewage would use up the oxygen immediately it was absorbed by the liquid, and therefore it would be impossible to aerate it thoroughly until the whole of the organic matter had been broken down, when the filter would not be required at all. Probably, before this could occur, a point would be reached at which the organisms, owing to lack of suitable environment and temperature, would cease to develop; but in order to reach this point the streams would have to be of such an enormous length as to render it quite impracticable. Besides this, the treatment of a septic effluent in the way suggested—and all sewage which had occupied any considerable time in travelling from the place of its production to the disposal-works was more or less septic—would give rise to an intolerable nuisance. He believed it was becoming generally recognized that the proper way to deal with a tank-effluent was to sprinkle it on to the surface of the filter intermittently, in small doses as quietly as possible, and to allow it to trickle slowly down in thin films over the surfaces of the grains of the material of which the filter was composed, the interstices being always full of air, so that the purifying organisms were cultivated on the surfaces of the grains, and could take up the oxygen they required from the air in the interstices, and destroy the organic matter in the films of liquid. Mr. Lowcock.

Mr. Hormusji Nowroji had observed, in somewhat accentuated forms, all the three classes of deposits enumerated by Professor Campbell Brown. A striking instance of incrustation was furnished by a system of water-supply, inaugurated in Mr. Nowroji.

Mr. Nowroji. for delivering potable water to Fort St. George, Madras. T system was still in operation, but the water was now us only for non-domestic purposes. The supply was derived fr wells in an extensive stratum of sand, which extended fr a few feet above subsoil water-level to an unascertained dep below the bottom of the wells. The supply was therefore whol abstracted from a sand stratum which was of a purely siliceo character. Presumably the water was naturally filtered. The was no trace of iron or acidity in it. Some of the cast-ir pipes in this system had been removed during the construction a sewer about 20 years ago. There had been incrustation in t pipes which occupied nearly one-half of their original area, and th was the condition of all the pipes in the system. The incrustati was hard and metallic, without any loose deposit of a vegetable earthy nature. Whatever little loose deposit there was appear to be disintegrated crust. Twenty years later, in 1903, he h had another opportunity of examining the pipes in the sar locality; and the incrustation did not appear to have advanc appreciably in that period. This supported Professor Brow observation that there was a limit to the growth of incrustatic These pipes had been in the ground, and had been conveyi water for the last 130 years. There was no record of the having been cleaned during that period. The second class deposit occurred in a remarkable degree in the Madras ci supply, introduced in 1872, which was obtained from a lar impounding-reservoir. The gathering-ground was covered main with laterite, an indurated ferruginous clay, in a gravelly or mo compact form; and there was cultivation as well as much natu vegetation on the gathering-ground. The water naturally contain some dissolved iron and much organic matter. The supply w unfiltered. The pipes had been coated before being laid; and t deposit in them, which was mainly of vegetable origin, was of fibrous appearance; in other respects it resembled peat. It som times accumulated to such an extent as to block the pipe co pletely. There was no incrustation on the inner surface of t pipes, but there was a thin metallic scale of a dark colour, whi retained its colour even after it had been scraped and exposed to t air. The deposit occurred mainly in the small-sized pipes with lo pressure. The obstruction to the flow of water caused by the deposi was so serious that 3 years ago the pipes had been cleaned on extensive scale. The result of this operation had been short-lived, f deposits were already forming in the cleaned pipes. The followi conclusions might be drawn from the foregoing observations. I

crustation in pipes could not be accurately described as a deposit; Mr. Nowroji.
it was rather an outgrowth of the metal forming the pipe: it was not derived from any constituent part of the water, nor from any matter contained in it. On the other hand, contact with water of a definite character appeared to be a requisite condition of the growth of incrustation. It was the result of some chemical change in the iron of the pipe, under the action of water. In the century-old pipes supplying Fort St. George, incrustation had been noticed on the outside of the pipes also, mainly at the flanges, the pipes being flanged. The theory was that leakage at the joints must have promoted incrustation in its neighbourhood. Examination of the circumstances attending the two kinds of deposits warranted the assumption that non-acid and organically pure water favoured the growth of incrustation. The action of water characterized by acidity would be to corrode and eat into the iron, and not to transform it into a spongy excrescence like incrustation. The obvious remedy against incrustation was an adequate protective coating to the pipes. The second class of deposit was quite unconnected in any way with the iron of the pipes. It was caused by organic impurity in the water, particularly if there was much of it in suspension. The theory that the conversion of this matter into a fibrous and peaty-looking stuff was due to bacterial action appeared to be tenable. In Madras, as probably in many other towns in the tropics, the pipe-water emitted a strong odour akin to sulphuretted hydrogen during the hot weather. When water issuing from a tap possessed this peculiar smell, it was a sure indication of a deposit in the pipe. The smell, which occurred only in the hot weather, could be satisfactorily explained upon the theory that the deposit was due to bacterial action. In the tropics rain fell within a limited period each year, and then followed a long spell of comparatively rainless months before the hot weather reached its height. The impounding-tanks were filled during the rainy months with water loaded with animal and vegetable matter, which passed into the pipes where filtration was not adopted—as in Madras—and provided food for the sustenance of myriads of bacteria. After the cessation of the rains, the water in the impounding-reservoir underwent a process of sedimentation; the suspended silt acted as a precipitant, and carried with it the organic débris contained in the water. In this and other ways the water in the tank was gradually freed from the organic matter as the hot weather advanced, and to a corresponding extent the f which sustained the bacterial life in the pipes diminished un reached an insufficient minimum, when the organisms die

Mr. Nowroji. untold numbers, and imparted to the water the peculiar odour mentioned. The correct remedial measure was to filter the water before it entered the pipes. The results which followed the large expenditure in cleaning the pipes in Madras had been very unsatisfactory, and proposals were now afoot for filtering and delivering the water at a sufficiently high pressure. Purity of water and a sufficient pressure of supply were conditions inimical to bacterial life. The water in the impounding-tank at Madras had never been known to emit any objectionable smell, which was due to the circumstance that the irrigation-sluices were several feet lower than the town-supply sluice. Tanks which emitted a strong smell in the hot weather were, however, not uncommon in Southern India. For the prevention of such smell, and also as a safeguard against the general deterioration of tank-water, the measure usually recommended was a scouring-sluice at the bottom of the tank, which would pass as much as possible of the surplus water. The most efficient treatment of water which emitted an unpleasant smell was to aerate it. The question as to how to do so economically and with little loss of head was not easy of solution. Speaking of the efficacy of aeration, a curious instance might be cited. He had been asked to report upon, and suggest measures for, an extensive tank near a large town, which emitted a very unpleasant smell every hot weather, and caused much discomfort in its neighbourhood. During the enquiry it had been elicited that, in the olden days, as soon as the smell became apparent a large herd of elephants belonging to the Rajah, whose palace stood at the margin of the tank, had been led into the tank, where they disported themselves, thus thoroughly agitating the water, and this invariably resulted in the disappearance of the smell in a day or two.

[illegible] Brown. Professor CAMPBELL BROWN, in reply, remarked that he would say corrosion was in the inverse ratio of the perfection of the deposit. Mr. J. E. Cornish had mentioned a perfect deposit (p. 64), which would completely protect a pipe against corrosion. Slimy deposits, being quite porous, afforded no protection against corrosion, which was the effect of oxidation, assisted more or less by salts and other substances dissolved in the water. The Bombay waters quoted by Mr. Bruce, as well as the Fort St. George water and the Nile water mentioned by Mr. Nowroji and Mr. Friend respectively, were of great interest, and the difference between the Tulsi [illegible] the other Bombay waters was very important. It was [illegible]hed that additional analytical details had been given, [illegible], in all cases, a minute observation of the reaction to

neutral litmus. This could be done either by means of neutral litmus-paper or by a filtered decoction very carefully neutralized. He had little doubt the Tulsi water showed an acid reaction. It would also be interesting to see the organisms in the various Bombay waters and their deposits, particularly those of the Tulsi water. Although in a comparatively small reservoir the action of wind and the flow of the water might be important, yet in a sufficiently large reservoir, such as a lake, it had been proved by observation and experiment that a much larger portion of the suspended impurities was discharged through an outlet near the bottom of the reservoir, than from an outlet a few feet below the surface. The variations in temperature in the British Isles were not wide enough to enable him to attribute substantially increased growth in pipes to the summer season. In hot countries, no doubt, the difference would be very marked; but the effect of temperature upon different kinds of agricultural growths would be different. High temperatures in the dark, as in pipes, would no doubt be chiefly objectionable in promoting the decomposition of dead organisms rather than accelerating the growth of living ones; while the growth of some would even be checked by a high temperature. Prof. Brown.

Messrs. CHADWICK and BLOUNT, in reply, thought that Mr. Fairlie Bruce, in expressing dissent from the arrangement by which the surplus water was discharged from the bottom of the reservoir, scarcely realised the peculiar conditions which obtained in the case of the Mare aux Vacoas. That lake was very shallow, not more than 6 feet or 7 feet deep at any point. It was originally choked with vegetation. The bottom was coated with a deep layer of peat-like matter, which communicated a dark-brown colour to the water. During heavy rain the incoming water of the tributary streams was relatively pure; it was at least free from vegetable matter. In the original state of the reservoir nearly the whole of this relatively pure rain-water escaped over the crest of the weir, leaving the strongly-charged substratum in store for distribution. In order to remedy this a Stoney sluice was introduced, large enough to discharge a moderate flood. Instructions were given to the man in charge that during heavy rain this sluice was to be raised sufficiently to prevent any overflow. The result of this was to discharge the lower strata of water, those most highly contaminated by long sojourn in the reservoir, whilst the relatively pure incoming stream-water was retained in the reservoir. The outlet to the district was also provided with sluices in tiers, one above the other, so that the Messrs. Chadwick and Blount.

Messrs. Chadwick and Blount.

purest surface-water might be drawn off for use. There however, another reason for the construction of the low-l sluice. It permitted of the water being lowered for the pur of removing the accumulations of dead vegetable matter from reservoir. These doubtless were the principal cause of the str contamination. During the rainy season, the water in reservoir was kept down to the lowest practicable limit. inflowing streams supplied ample water for the wants of district. The water merely passed through the reservoir, witl storage, and therefore with the minimum amount of contaminat By keeping down the water-level, the work of removing l living and decayed vegetation was greatly facilitated. T could be no doubt that in the present case the system of drav the supply from near to the surface and discharging surplus w from the bottom of the reservoir was productive of good res The water, which before the cleansing operations were underta was so charged with suspended gelatinous vegetable matter a be practically unfilterable, became filterable. This result doubtless to some extent due to the removal of vegetation and products of its decomposition, but as it had not been pos thoroughly to cleanse the reservoir, some share in the improver must be attributed to the method of discharging surplus w from the bottom and drawing the supply from the surface of reservoir. Messrs. Chadwick and Blount were prepared to l that the Nile water might require treatment different from which they had found effective for other tropical waters. Nile w carried with it its own defecating agent in the shape of finely div clay, and if this were coagulated by the addition of a precipi such as sulphate of alumina, a great increase in organic purity m be expected. In the case of the waters with which they had to deal, the problem was not so simple; there the organic ma needed something more than defecation for its elimination, they had been driven to a more drastic method. The observat of Mr. Friend were interesting as tending to show that "limon" present in the Nile water acted as a coagulant; it w matter of traditional knowledge that though Nile water neither pleasant to the eye nor good for drinking in its raw s yet when allowed to subside even in small vessels, its gross purities were deposited, and in their deposition much prom the purification of the water from the more subtle form contamination. They ventured to dissent from Dr. Ken suggestion that the purification of water by means of iron solely due to the precipitating action of ferric hydroxide.

no doubt occurred, but *per se* it could not account for the resolution of nitrogenous organic matter which was proved by their analyses. It seemed to them preferable to regard the change as brought about by the unstable state of precipitated oxide of iron, which served as an excellent carrier of oxygen. The ferric hydroxide finally formed was a precipitant precisely as was alumina, but before this stage the oxide had acted as an oxidising agent. One of the waters mentioned in the Paper (that from the pond at Rowledge) was derived from the very district mentioned by Mr. Lowcock, but the similarity of origin did not connote identity of quality. It appeared from Mr. Lowcock's communication that the water at Farnham was aerated chiefly for the purpose of removing iron; that by itself was not a difficult matter, and could be accomplished by simple means. The real difficulty arose when the iron was so intimately associated with organic matter, probably as a complex ion, that its oxidation and deposition needed persistent aeration. Even when common ferruginous waters were treated, it might be found economical to use perforated plates instead of the ordinary fountains. Messrs. Chadwick and Blount admitted freely that the utilization of their apparatus for the treatment of sewage would require experiments; they in no way put it forward as suitable in its present form, but believed that the principle was sound and that it might be applied for this purpose.

Messrs. Chadwick and Blount.

22 December, 1903.

Sir WILLIAM H. WHITE, K.C.B., D.Sc., LL.D., F.R.S., Presi
in the Chair.

(*Paper No. 3465.*)
(*Communicated from the National Physical Laboratory.*)

"On the Resistance of Plane Surfaces in a Uniforn Current of Air."

By Thomas Ernest Stanton, D.Sc., Assoc. M. Inst. C.E.

The Committee of the National Physical Laboratory ha decided that one of the first researches to be undertaken ir Engineering Laboratory should be the investigation of the d bution and intensity of the pressure of the wind on structui scheme on the lines on which it was proposed to work submitted by the Author, as Superintendent of the Engine Department, to Dr. R. T. Glazebrook, F.R.S., Director of Laboratory, in January, 1903, and, being approved by him work of constructing the apparatus was at once commenced.

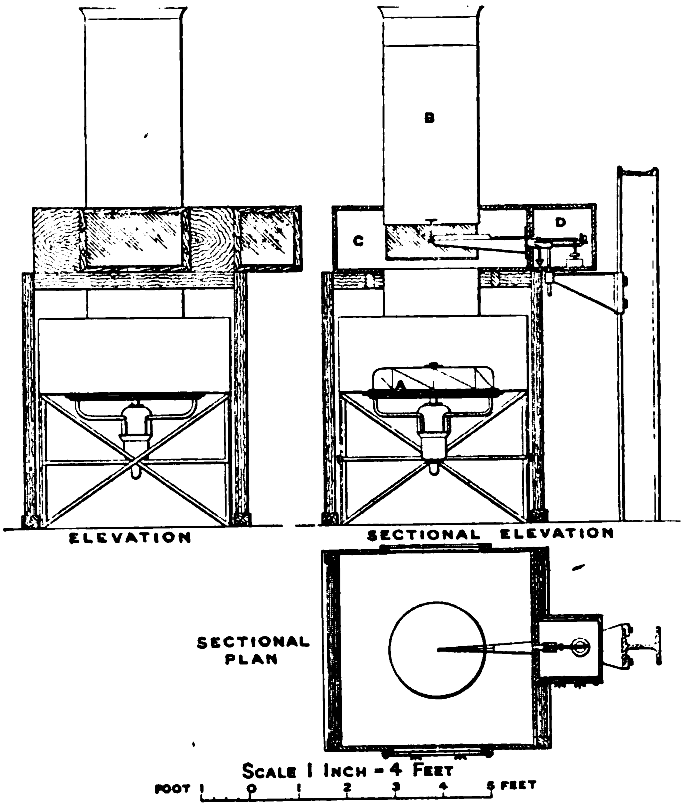
The first part of the research suggested in this scheme v preliminary investigation of the resultant pressure, and the d bution of pressure, on flat plates, singly and in combination, uniform current of air, and, if possible, the determination general relation between the velocity of the current, the di sions of the plates and the resultant pressure. By a uni current of air is meant a current in what is known as "edd motion," as distinguished from "stream-line motion," the 1 velocity in the direction of flow being uniform across the cur this condition of motion being considered the nearest approxim to that of winds of fairly high intensity. The reason for su preliminary investigation was that, although many valı researches on the subject have been published in recent years apparatus employed in the majority of cases has not lent itse a study of the distribution of pressure on the plate, or of the of its form and general dimensions; and further, that experin in the open air could not be undertaken with any prospe success until some general relation of the kind had been establi it having been conclusively proved that the mean intensit

pressure on a plate is considerably influenced by its form. It was therefore considered necessary to make the experimental apparatus of such a nature that a considerable number of experiments on plates of varying forms could be rapidly carried out. This condition was the important factor in the plan adopted, which was the production of a uniform current of air in a channel of fairly large dimensions by means of a fan, the speed of which could be varied within wide limits. Some hesitation was experienced from the consideration of the effect of the walls of the channel on the distribution and intensity of the pressure; but it was hoped that by adopting methods of measurement of considerable delicacy it would be possible to make experiments on plates, whose dimensions relative to those of the channel would be so small as to preclude any possible action of the walls.

Description of the Apparatus.—The direction of the current was made vertical and downwards on account of the obvious advantages of working. The general form of the apparatus is shown in *Figs.* 1 and 2. A is a Blackman fan 2 feet 6 inches in diameter, driven by an electric motor which is provided with two speed-regulators, one for considerable variations, and a carbon resistance for small variations. The air is drawn downwards through the channel B, which is 2 feet in diameter and 4 feet 6 inches in length, and terminates in a rectangular box C, 4 feet by 4 feet by 1 foot 3 inches in depth, provided with glazed air-tight shutters, the front shutter being clamped by wing-nuts, and affording access to the chamber for the purposes of placing the plates in position and adjusting the pressure-measuring apparatus. At the side of this box is a smaller compartment D, in which is placed the lever and jockey-weight for the measurement of resultant pressures. The lower end of the compartment C is connected by means of a short length of pipe, 2 feet in diameter, to the fan-chamber. The arrangement for measuring resultant pressures on plates is shown on a larger scale in *Fig. 3.* The experimental plates are mounted on a spindle S, made of drawn steel tubing, which is screwed into the extremity of a lever L, the knife-edges of which are carried by the standard P in the chamber D, and the short arm of which is provided with a graduated scale and jockey-weight for measuring the pressure. The standard P is carried by a bracket which is bolted to one of the main stanchions of the building, and is unaffected by any vibrations of the fan-casing. At the end of this weighing-lever there is a scale-pan with a dash-pot for damping the vibrations of the plate and lever. The dash-pot consists of a perforated brass disk in an oil-reservoir.

For the purposes of the measurement of the intensity of the a pressure on the plates at any point, the long arm of the leve made hollow, with nozzles at the extremity in the air-chan communication with the other extremity being made by the sh length of tube V, parallel to the knife-edges. Thus, by connect the point at which the intensity of pressure is required to of the nozzles, and attaching a flexible tube to the tube V, wh

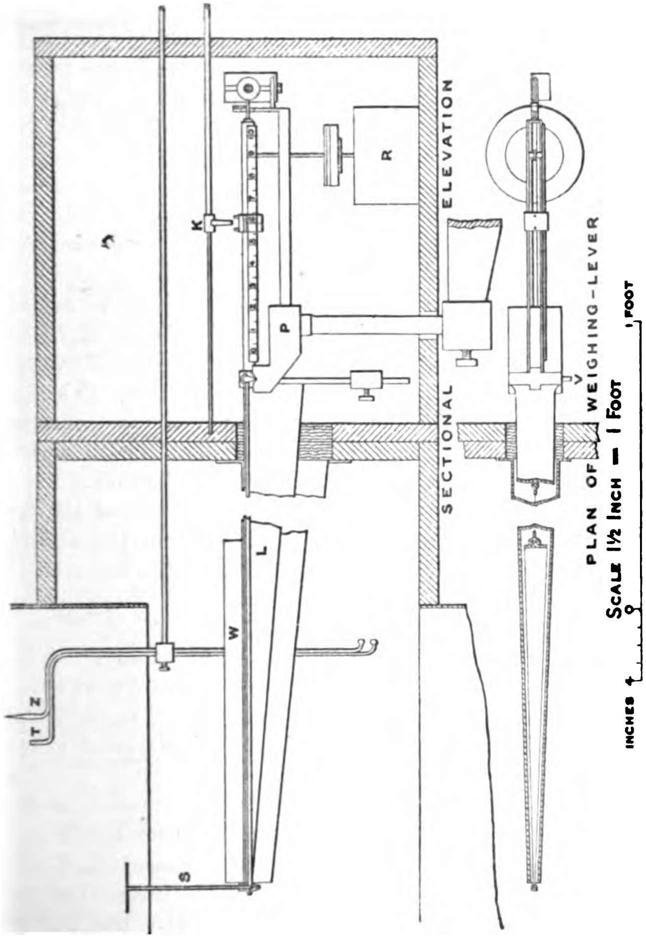
Fig. 1. *Figs. 2.*



can be connected to a pressure-gauge, the pressure is ea determined. The part of the lever which projects into the channel is provided with a wind-guard W, to ensure that resultant pressure is that due to the experimental plate alone. prevent any passage of air through the wind-guard, the cham D is also provided with glazed air-tight doors, the adjustmen the jockey-weight being made by the brass slider K.

For successful working it was necessary that the velocity of the current should be practically uniform across the channel, and considerable difficulties were experienced in effecting this result. On first setting up the apparatus and using the fan it was found that the velocity of the current was a maximum at half the

Figs. 8.



radius, the velocity at the centre being about 95 per cent. of this, owing to the effect of the boss of the fan. Ultimately, by varying the length of the suction-channels, and also by introducing layers of gauze at certain points along the channel, an approximately uniform current was set up, the degree of accuracy obtained being a variation not exceeding 1 per cent. of the mean

velocity of the current over a region extending to a distanc 1 inch from the walls of the channel. With a current prodı under these conditions it was found that at all speeds which c be obtained in the apparatus (*i.e.*, between 5 feet per second 30 feet per second) the air was in a state of eddying motion, observed effect on silk threads suspended in the current b apparently the same as that indicated in a stiff breeze.

Estimation of the Speed of the Air-current.—As it was necessar be able to estimate the velocity of the current accurately rapidly at various points of the channel, as distinguished from mean velocity over a considerable part of its area, the simp and best method seemed to be that of measuring the velocity-l of the current as given by the pressure in a Pitot tube, toge with the measurement of what may be called, for convenience, static pressure of the air in the current, in the neighbourhoc the position of the Pitot tube. The arrangement finally adop and which proved very satisfactory, is illustrated in *Figs. 3*, consists of two tubes of drawn steel, $\frac{1}{8}$ inch in diameter, conne to a very sensitive water-gauge. The Pitot tube T has a t lipped orifice facing the current, the tube Z for measuring static pressure having a conical stopped end with small h perpendicular to the axis immediately below the cone. Expres the difference of pressure in the two tubes in feet of air, h, at statical pressure and temperature of the air in the channel, velocity v of the current was calculated from the formula—

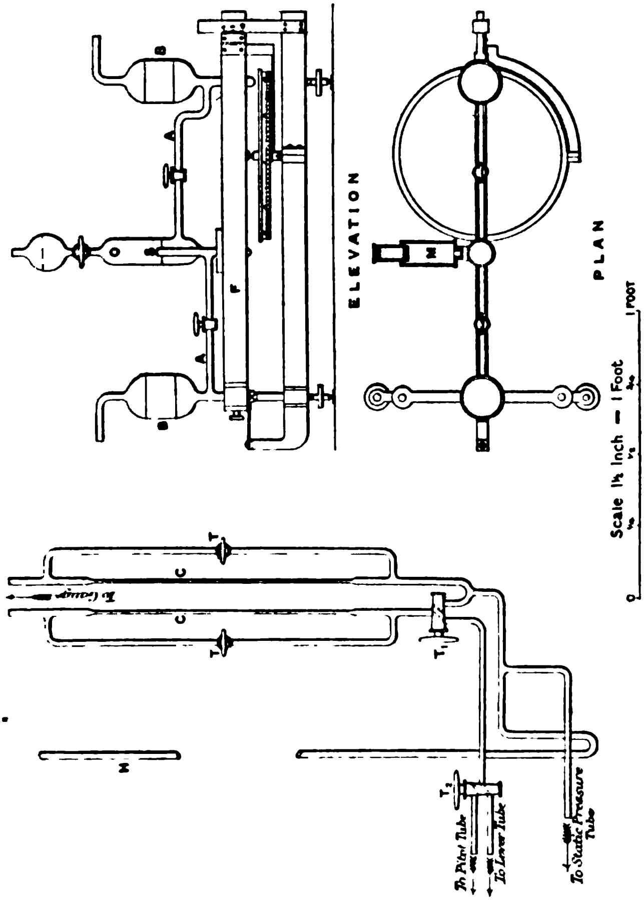
$$v = k \sqrt{2 g h}$$

in which k is a constant to be determined by experiment, its v not differing greatly from unity. The two tubes were attache a holder which could be moved radially across the channel wall to wall for the purpose of detecting variations of spee the current.

Measurement of the Intensity of the Air-pressure, and of Velocity-head in the Pitot Tube.—For this purpose a tilting wa gauge, specially designed and made by Professor A. P. Chat and Mr. J. D. Fry for these experiments, was used. The princ of this gauge is that of a U-tube in which the differenc pressure on the two surfaces of the water in the limbs of the si measured by tilting the gauge through a very small angl that there is no displacement of the water along the tube, ins of actually measuring the relative vertical displacement of surfaces. By this means the errors due to capillarity ·cosity are avoided. A special kind of oil is introduced int

horizontal limb of the gauge, so that any small displacement can be detected. The form of the gauge adopted is shown in *Figs. 4.* B B are the enlarged extremities of the U-tube, the arms A A being turned upwards at the centre and meeting concentrically in the oil-chamber O, which communicates at its upper extremity with an oil-reservoir through a tap. The surface of separation of the oil and

Figs. 4.



the water in the arm to the left is shown at S, and in the arm to the right a little below it. By means of taps in the arms which may be closed, the gauge is rendered portable. The gauge, which is of glass, is mounted on the brass frame F, which itself rests on three hardened steel points as shown in *Figs. 4*, one of which is in the axis of the spindle and wheel, by means of which the tilting is

measured. The motion of the surface of separation S is noted b means of the microscope M, which is fixed to the frame F. I working, any slight difference of pressure on the water-surface in the bulbs B B produces a displacement of the surface S, whic the observer corrects by rotating the hand-wheel, tilting the gaug and bringing the surface to coincide again with the hair-line the microscope. The movement of the gauge is then read off o the hand-wheel scale and the difference of pressure is calculate In the majority of the experiments the differences of pressure be measured on the gauge were so great that it was impossible adjust the hand-wheel sufficiently rapidly to prevent a serio displacement and rupture of the surface S; a wire-drawing devic was therefore adopted, and is shown on the left in *Figs. 4*. By thi means when the gauge was connected to the Pitot tube the ta T T were kept closed, and communication with the gauges too place only through the capillary tubes C C, and consequently th pressure was brought on very gradually, and the displacement the surface S was kept under control. The taps T T were the opened before taking the actual readings. It was also foun necessary to observe the zero-reading of the gauge after eac experiment, owing to the changes of temperature of the wate For this purpose the three-way tap T_1 was provided, by means which the two limbs of the gauge could at once be put int communication. Another three-way tap T_2 was inserted in th "pressure" tube of the gauge, to enable this to be utilized, eithe for the determination of the speed of the current by connecting to the Pitot tube, or for the measurement of the intensity pressure at any point on a plate, by connecting it to the leve tube. The tube on the left was attached to the static pressur tube, with a branch-connection to the barometer H, as shown i *Figs. 4*.

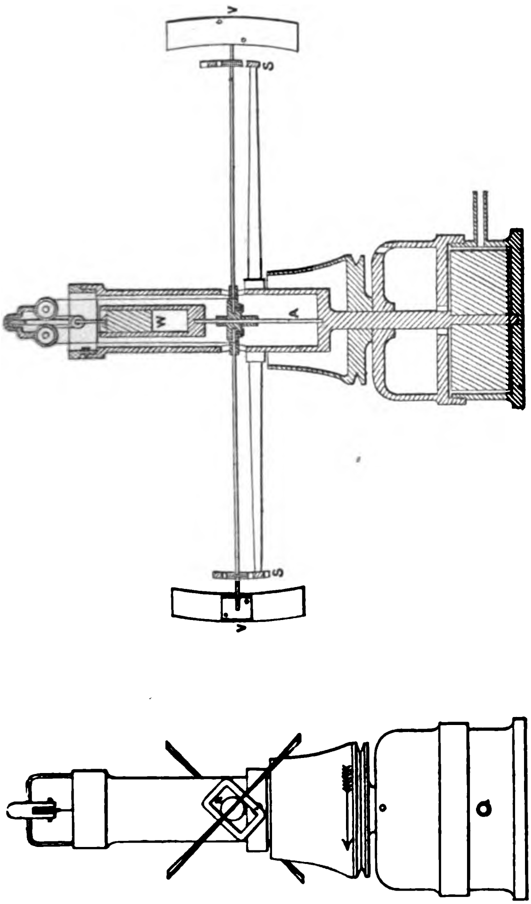
Degree of Accuracy of the Measurement of the Pressures.—I the case of the estimation of the resultant pressures by means the lever and jockey-weight, the graduation of the lever was suc that the movement of the jockey-weight through the whole scal represented a pressure at the end of the long arm of 0·01 lb. Th scale was divided into 100 parts, the readings being easily take to one-tenth of a division, representing 0·00001 lb., and unde working conditions the knife-edges were found to be sensitiv enough to indicate a difference of pressure of this amount.

In the case of the tilting pressure-gauge, the dimensions wer such that one revolution of the hand-wheel corresponded with difference of head of 0·065 inch of water. The scale set out o

the wheel-rim was 100 divisions per revolution, and the sensitiveness of the gauge was such that a movement of the wheel of one-tenth of a scale-division could be detected by the microscope, so that by this means pressures could be estimated to 0·000002 lb. on the square inch, or 0·00006 inch of water.

It will be seen by reference to the tabulated results of the experi-

Figs. 5



SECTIONAL ELEVATION

Scale 4 Inches = 1 Foot.

0 1 2 3 4 5 6 INCHES

AIR-METER FOR VERTICAL CURRENTS.

END ELEVATION

ments that these degrees of accuracy were absolutely necessary on account of the dimensions of many of the plates used; and without them the conclusions arrived at could not have been established.

Calibration of the Pitot Tube.—For the purpose of deducing the speed of the air-current from the readings of the gauge when connected to the Pitot tube and the static pressure-tube, a special

form of air-meter was designed by the Author, by means of whi the velocity of the current could be measured directly, and the val of the constant in the Pitot-tube formula be determined. Th air-meter is illustrated in *Figs. 5*. V V are two narrow aluminiu vanes fixed at the extremities of two light steel radial arms, whi are connected at their inner extremities to a small brass slee which can move freely up and down the steel spindle A. T

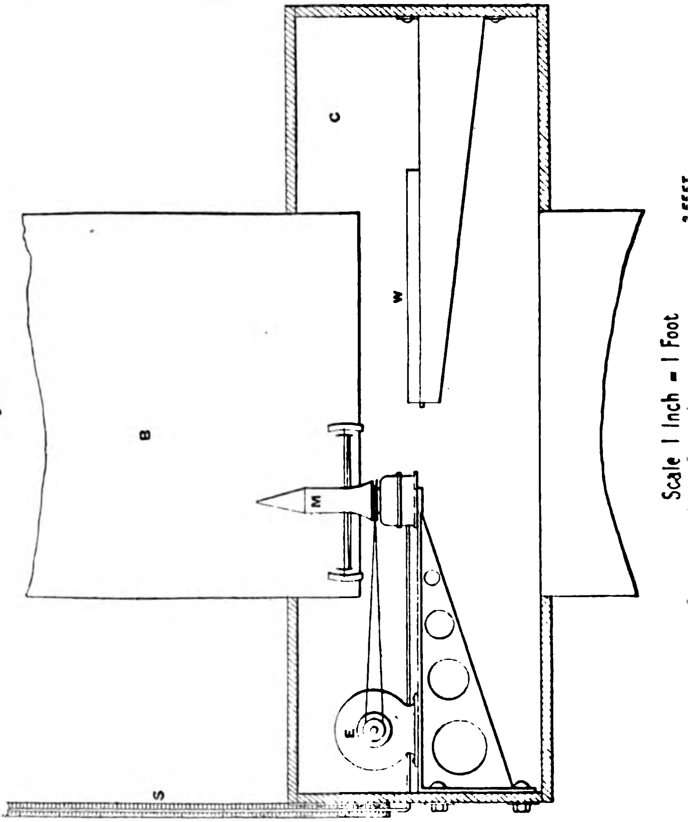


Fig. 6.

form of the vanes is such that the intersections with them cylinders coaxial with the axis A are helices, the pitches of wh are proportional to the radii, the inclination of the helices bei 45° to the horizontal. The vanes, arm and sleeves are carried two small rollers R R, which can move in the short helical pa shown, these paths being also inclined at 45° to the horizontal, normal to the helices of their respective vanes. These heli

paths are supported by the steel spindles S S, which are fixed to the spindle of the air-meter. The effect of gravity on the vanes and arms is counteracted by the balance-weight W, which is connected to them by a silk thread moving over the two pulleys, as shown, so that, when the spindle is rotated at a uniform velocity, the only force tending to make the wheels move up or down the helical paths is the air-pressure on the vanes, and it is evident that when the effect of the air on the vanes is wholly tangential there will be no tendency to move up or down. If the instrument be placed in a vertical downward current of air, moving at a velocity of V feet per second, and the spindle of the air-meter be rotated in the direction indicated by the arrow—at such a speed that the mean velocity of the vanes is v feet per second—then, considering the velocity of the air relative to the vanes, it is clear that if V be greater than v the air-pressure will tend to force the vanes down the helical path, and if V be less than v the vanes will rise. When V is equal to v, the motion of the air relative to the vanes being tangential, and the pressure on them normal to the helical path, the vanes will be stationary.

The instrument described was made in the laboratory and was set up in the experimental channel, being driven by a small motor placed in the large rectangular compartment. The general arrangements are shown in *Fig. 6*. For the purposes of rapid estimation of the speed of the vanes, the spindle of the meter is utilized to drive a speed-indicator either directly below it, as shown in the Figure, or by a cord. The speed-indicator consists of a fan working in a cylinder which is supplied with water from a reservoir at the top. A pipe from the cylinder is connected to the vertical glass tube, carrying a scale S, which is calibrated so that the velocity of the vanes in feet per second can be noted from the height of the column of water in the tube. In working, the instrument was found to be extremely sensitive, a change of speed in the air-current which could hardly be detected by the pressure-gauge causing the vanes to move up or down. The results of the calibration of the Pitot tube at two different speeds are given in the following Table:—

Velocity Head of Current (from Gauge-readings).	Revolutions of Meter Per Minute.	Velocity of Vanes.	Value of k.
Feet.		Feet Per Second.	
3·03	362	14·40	1·030
6·10	515	20·48	1·032

On the assumption of the accuracy of the air-meter, the value o the constant, k, for the particular form of Pitot tube used in thes experiments, is, therefore, 1·03, indicating apparently that th observed value of the pressure in the static-pressure tube wa slightly in excess of the true static pressure of the air; and it this value which has been used in all calculations of velocit which have been made for the purposes of this Paper.

Influence of the Walls of the Channel.—Before the detaile observations required for the research could be commenced, it wa all-important to determine the maximum dimensions of plate whic could be employed without being subject to any effect of th walls of the channel on the intensity and distribution of th pressure. As it seemed possible that considerable light would b thrown on this question by observing the resultant pressures o plates of varying area, a set of circular disks was prepared, th diameters varying between ½ inch and 5 inches. Observatior were made on these in an air-current the velocity of which was kep constant, the Pitot tube being placed at a distance of 1 foot abov the plate in each case. The results are given in the followin Table:—

EXPERIMENTS ON CIRCULAR PLATES.

Velocity head of current = 5 feet.

Diameter of plate in inches . .	0·5	1·0	1·5	2·0	3·0	4·0	5·0
Mean pressure in pounds per sq. inch	0·00294	0·00302	0·00300	0·00297	0·00324	0·00345	0·003[illegible]

It will be seen that, although there is, as is well known, con siderable variation of the pressure from the centre to the circum ference, yet the mean intensity of pressure is practically the sam for the small plates up to a diameter of 2 inches and then rise rapidly, the intensity of pressure on the 5-inch plate being [illegible] per cent. greater than that on the 2-inch plate. This is possibl due to the effect of the walls of the channel. As a prelimina test a two-armed spindle was made, each arm carrying a dis 2 inches in diameter at a distance of 8 inches apart. In this ca the mean pressure was found to be 9 per cent. greater than tha found for the single disk. On trying four 2-inch disks on a sing spindle the mean pressure was found to be 16 per cent. great than that indicated on the single disk.

This would certainly appear to indicate a wall effect in the ca of disks exceeding 2 inches in diameter. Further confirmatio

was sought in the measurement of the velocity of the currents in the region near the walls when disks of varying diameter were placed at the centre. It will be seen from the following Table that for plates exceeding 2 inches in diameter the velocity in the neighbourhood of the walls is appreciably affected:—

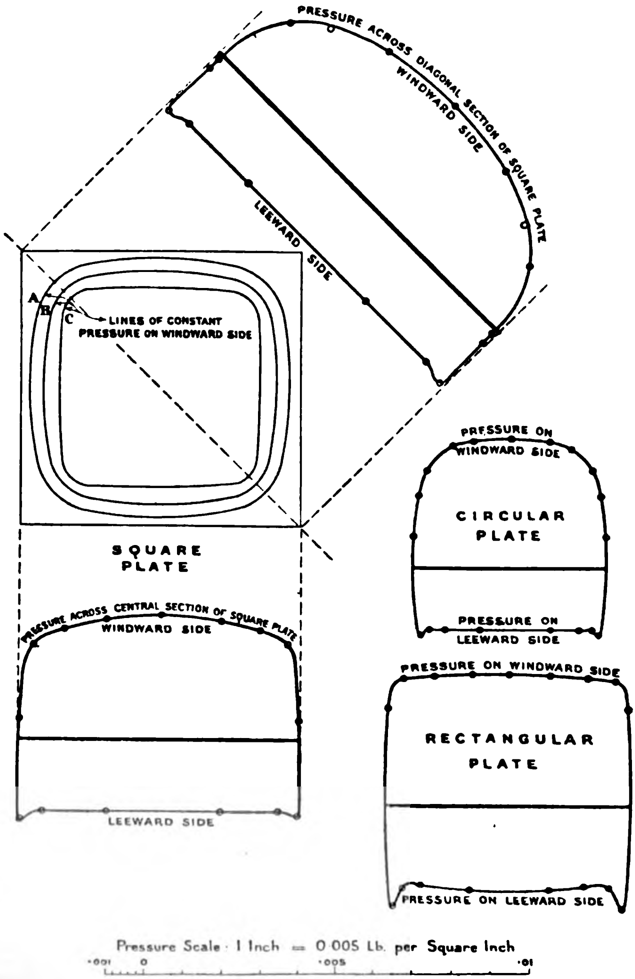
—	Velocity of Air-Current before reaching Disks.	Velocity of Air-Current at a Radius of 10 Inches in the Plane of the Disk.
	Feet per Second.	Feet per Second.
No disk	18·8	18·6
Disk 2 inches in diameter . .	18·6	18·4
" 3 " " . .	18·8	19·1
" 4 " " . .	19·0	19·4
" 5 " " . .	19·0	19·6

The conclusion arrived at from these experiments was that the influence of the walls of the channel could be neglected only for the case of single disks not exceeding 2 inches in diameter, and this was further justified by the subsequent study of the distribution of pressure on the plates. Thus the limiting area of models used in such an apparatus as the one here described appears to be approximately 0·7 per cent. of the area of the experimental channel. The very considerable influence of the walls when the area of the plate is as much as 4 per cent. of the channel is apparent from the results quoted.

Distribution of Pressure on Plates on which a Current of Air impinges normally.—In order to analyze the resultant pressures on plates, and if possible to obtain more light on the observed effect of the sides of the channel, a set of observations was made to determine the distribution of pressure on plates of various forms. As is well known, if the datum of pressure be taken as the static pressure of the current as previously defined, the pressure on the windward side of the plate is positive, and that on the leeward side negative. This negative pressure on the leeward side of the plate is a factor of considerable importance in the resultant pressure, and is the reason of the well-known fact that the resultant pressure on a thin plate is considerably in excess of the values deduced from theoretical considerations which neglect the leeward pressure. The results obtained from circular, square, and rectangular plates are given in the Appendix, Table I., and three typical cases are plotted in *Figs.* 7, A B and C being lines of equal intensity of pressure. On examining these results the chief points of interest are:—

1. That the intensity of pressure at the centre of the windward

Figs. 7.



CURVES OF INTENSITY OF PRESSURE.

side of all the plates is constant for any given velocity of the current, and is equal to

$$\frac{1}{2} \rho V^2$$

where ρ = density of the current,
V = velocity of the current.

2. That the intensity of pressure on the leeward side is practically uniform except near the edges, and that its value varies with the form of the plate. As an example of this, the ratio of the maximum pressure on the windward side to the pressure on the leeward side of a circular plate is found to be 2·1 to 1, whereas the ratio for the rectangular plate used was 1·5 to 1.

3. That this ratio was only constant in this apparatus for similar plates so long as the area of the plate did not exceed a certain value, which for circular plates was about 3·2 square inches, the effect of the walls of the channel being chiefly apparent in a numerical increase of the negative pressure on the leeward side. Thus the pressure on the leeward side of a plate 5 inches in diameter was approximately 40 per cent. greater numerically than the pressure on a plate 2 inches in diameter. It is possible that this accounts for the large values of this negative pressure which have been recorded in experiments on models placed in an experimental channel.

It may also be noted, in support of the conclusion that the 2-inch disks were unaffected by the walls of the channel, that the ratio of the pressure on the leeward side of these plates to the pressure at the centre of the windward side was precisely the same as that found by Mr. Dines [1] in his experiments with a plate 1 foot square in a whirling-machine.

General Case of the Resultant Pressure on Flat Plates in a uniform current which impinges normally.—From a careful comparison of the curves of pressure obtained from experiments on circular plates of varying diameter, a striking radial similarity in the curves of pressure on the windward side was apparent. This, together with the fact previously mentioned that the practically uniform pressure on the leeward side was simply dependent on the form of the plate, suggested the conclusion that possibly in all similar plates the intensity of the pressure at corresponding points would be the same, and consequently the mean resultant intensity of pressure on similar plates would be constant for a given speed of current. In order to verify this in a simple case two square plates were prepared, 1·76 inch by 1·76 inch and 0·88 inch by 0·88 inch, and pressure-holes were made at points distant from the edges respectively 0·2 inch and 0·1 inch. On determining the pressures on the windward side at these points, these were found to be in close agreement when exposed to the same current of air, and this was also found to be the case on the leeward side. On determining the resultant

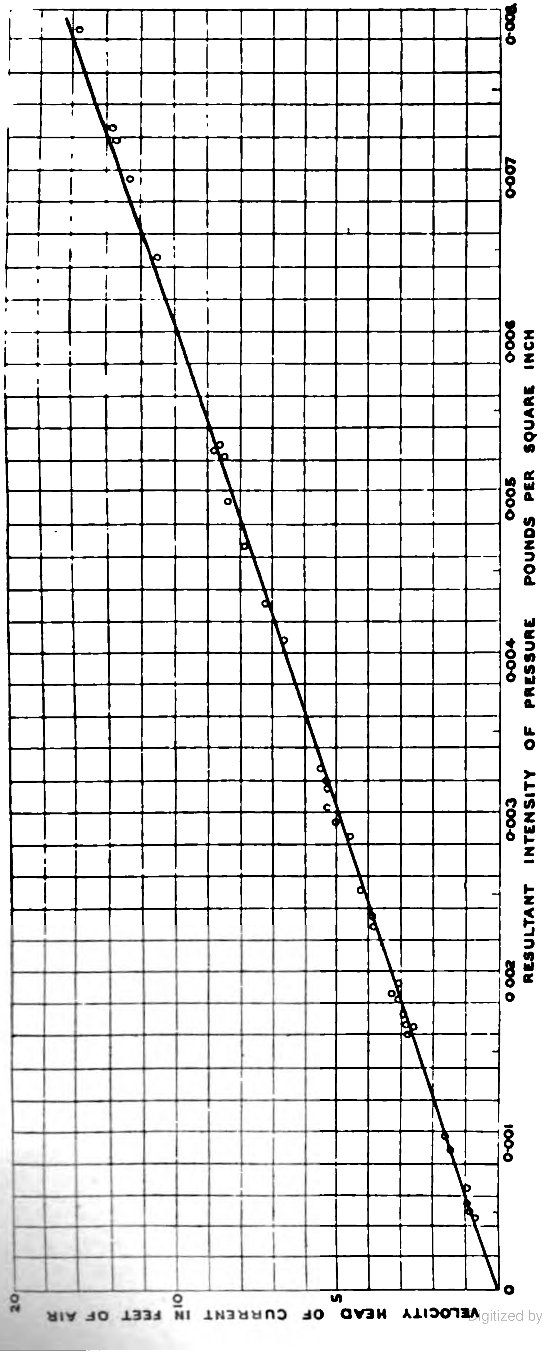
[1] Quarterly Journal of the Meteorological Society, vol. xvi. p. 210.

pressures on these plates separately, further confirmation was obtained, the mean intensity of pressure being the same in each case.

As it was of the greatest importance that this conclusion should be thoroughly investigated, a large number of experiments were made on plates of various forms, the resultant pressures being determined at speeds varying between 5 feet and 30 feet per second. The following cases were treated, and the results are tabulated in the Appendix:—Circular plates (Table II.), square plates (Table III.), rectangular plates (Table IV.) and lattice models built up of rectangular plates (Table V.).

The result conclusively established was that for similar plates and similar lattice models, within the limits of area imposed by the dimensions of the experimental channel, the mean intensity of pressure was the same for the same velocity of current and general atmospheric conditions. Owing to the limits imposed by the dimensions of the channel, the range of area for similar plates could not be very great, but in the Author's opinion it was sufficiently large to justify the foregoing conclusion. Thus in the case of the circular plates the diameters ranged between $\frac{1}{2}$ inch and 2 inches, the former being the diameter of the smallest plate on which the resultant pressure could be accurately estimated. The results for the circular plates are also plotted in *Fig. 8*, in which the ordinates represent the values of the velocity-head of the current at the various speeds, and the abscissas the mean intensities of pressure on the plates. The grouping of these points about the straight line drawn through them shows that the pressure varies as the square of the speed within the limits reached in the experiments. It will be seen from the diagram that there is a slight deviation from proportionality at the highest speeds, which is probably due to the velocity in the centre of the channel being slightly greater than the mean at the high speeds. As these results were obtained on days on which the height of the barometer and the temperature varied, it was necessary to reduce them to a standard pressure and temperature. Assuming, as there seems no reason to doubt, that apart from the variable viscosity of the air, the pressure at a given speed will vary as the density of the air, the results obtained were all corrected for density and reduced to their values at an atmospheric pressure of 14·7 lbs. per square inch and a temperature of 60° F. The reasons for expressing the results at this temperature are, to enable a comparison to be made with the results of other experimenters, the majority of which took place at or near this temperature; and also because of the

Fig. 8.


RESULTANT INTENSITY OF PRESSURE POUNDS PER SQUARE INCH
0
0·001
0·002
0·003
0·004
0·005
0·006
0·007
0·008
VELOCITY HEAD OF CURRENT IN FEET OF AIR
5
10
20

undoubted effect of the viscosity of the air, which, so far as the Author's experience goes, is sufficient to neutralize the variations of the density-factor, and renders readings at a high temperature as large as, or greater than, those at a low temperature. Mr. Dines,[1] in his experiments with plates on a whirling-machine, found a similar effect to exist for considerable ranges of temperature.

Neglecting the viscosity effect, the inclination of the straight line in *Fig. 8* gives the relation between pressure and speed of current, according to the methods of estimation described, for the case of the circular plates. Thus, if v denote the velocity of the current in feet per second, and P the resultant pressure in pounds per square foot, then, for circular plates—

$$P = 0 \cdot 00126\ v^2$$

or, in other units of velocity, if V be the velocity in miles per hour—

$$P = 0 \cdot 0027\ V^2.$$

The results for the square plates (Appendix, Table III.) appear to be identical with those for the circular plates, the value of the constant being precisely the same in the two cases. The following results have been obtained by experimenters in other investigations:—

Dines[2] . . $P = 0 \cdot 0029\ V^2$ (square plate)
Froude[3] . $P = 0 \cdot 00366\ V^2$
Langley[4] . $P = 0 \cdot 00326\ V^2$ to $0 \cdot 0039\ V^2$ (square plate)

The results for similar rectangular plates are given in the first part of Table IV. in the Appendix, the cases taken being plates for which the ratio of length to width was 5 to 1 and 10 to 1.

For similar lattice models the form shown in *Fig. 12*, No. 1, was adopted, of which three were used, of relative sizes 1, $\frac{3}{4}$, and $\frac{1}{2}$. It will be seen from Table V. (Appendix) that the intensity of pressure, although 25 per cent. higher than in the case of square plates, is the same for all sizes of the models at the same speed of current.

Pressure on Dissimilar Plates.—The mean resultant pressure on dissimilar plates was found to vary considerably for the same speed of current, the mean pressure on a long narrow rectangular

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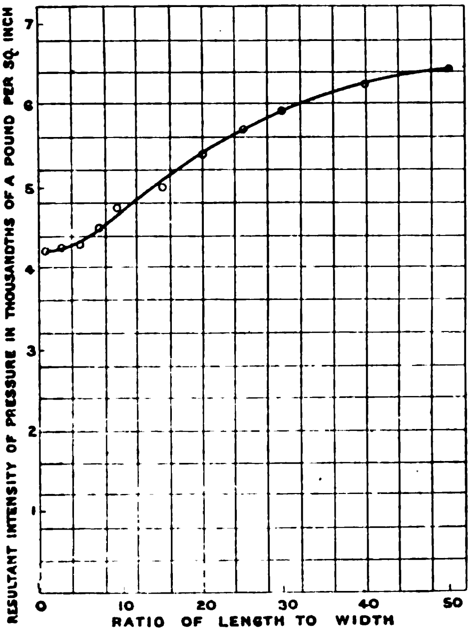
e Royal Society, vol. xlviii. p. 252.
. 253.
A Manual of Naval Architecture," 3rd ed. p. 491. London,
"Experiments in Aerodynamics," (Smithsonian Contribu-
1), p. 99. Washington, 1891.

plate being nearly 60 per cent. greater than that on a circular one. It has been previously mentioned, in discussing the intensity of pressure, that the intensity of pressure on the leeward side of a rectangular plate is greater than that on circular and square plates. Further observations showed that the numerical value of this intensity increases as the ratio of length to width increases. In order to determine the variation in the mean resultant pressure, a set of experiments was made on plates in which the ratio of length to width ranged from 1 : 1 to 50 : 1. The results are given in the Appendix, Table IV., and are also plotted in *Fig. 9*, the curve

Fig. 9.



PRESSURE ON RECTANGULAR PLATES.

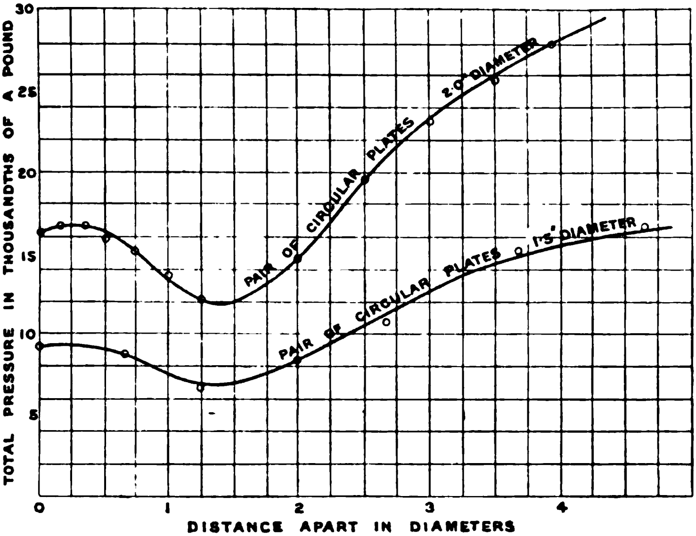
showing the relation between the mean resultant pressure and the ratio of length to width. It will be seen from the diagram that the variation is considerable, and in approximate agreement with the results obtained by Mr. Dines[1] for plates having a ratio of length to width of 16 to 1 and 4 to 1.

Pressure on Parallel Plates.—The important case of the shielding-effect of a plate placed symmetrically in front of a plate

[1] Quarterly Journal of the Meteorological Society, vol. xv. p.

of the same dimensions was carefully examined, in view of the disagreement of the results obtained by previous experimenters. The first case tried was that of a pair of circular plates 2 inches in diameter. These were placed on a screwed spindle so that the position of the lower plate could be varied and the total pressure measured for the different positions, the velocity of the current being kept constant throughout. The results obtained are given in Table VI. (Appendix) and plotted in *Fig. 10*, in which are also given the values obtained for a pair of plates $1\frac{1}{2}$ inch in diameter. The most interesting feature brought out is the considerable reduction in the total pressure when the distance between the

Fig. 10.



PRESSURES ON PARALLEL PLATES.

plates is approximately $1\frac{1}{2}$ times the diameter, the value of the total pressure at that distance being less than 75 per cent. of the resistance of a single plate. This led to the conclusion that possibly in this position the resultant pressure on the lower plate would be in a direction opposite to that of the current. In order to verify this a single plate 2 inches in diameter was attached to the arm of the lever and balanced before the air-current was set up. A second 2-inch plate was then fixed in a position 3 inches above the floating plate and the air-current was turned on. The lower plate was at once drawn upwards, and by means of the jockey-weight the actual amount of the resultant upward pressure was determined.

On increasing the distance between the plates this effect diminished until at a distance of approximately 2·15 diameters the total pressure on the two plates was equal in value to that on a single plate. The total pressure then increased as the plates were moved farther apart, but the shielding-effect was well maintained, for, at a distance of 5 diameters, the total pressure was only 1·78 times that on the single plate. The values of the total pressure at distances of 3 diameters, 4 diameters and 5 diameters apart agree closely with those obtained by Sir Benjamin Baker in his experiments at the Forth Bridge. Experiments on square and rectangular plates gave corresponding results, it being found that the shielding-effect of long rectangles was considerably less than in the case of circular plates, but in all cases the maximum shielding-effect was observed when the plates were at a distance apart of approximately 1·5 times the least cross dimension. It is apparent from the two curves in *Fig. 10* that the shielding-effect with circular plates for a given distance apart depends simply on the ratio of that distance to the diameter of the plate; and it was considered important to discover what the conditions were for similar plates of more complicated form. For this purpose three pairs of similar lattice models were made, of the form shown in *Figs. 12*, No. 1, of relative sizes 1, ¾, and ½. The results obtained are given in the following Table, which shows that for the similar lattice models similarly situated the shielding-effect is precisely the same:—

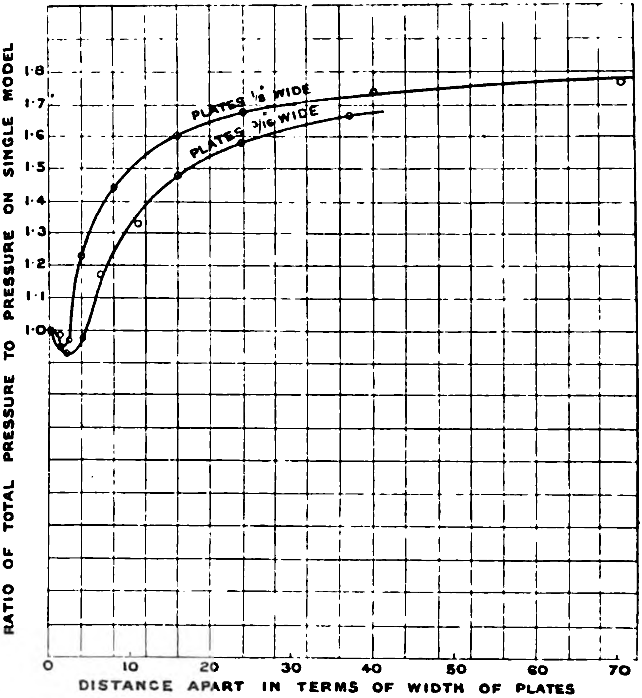
Model.	Velocity Head of Current.	Total Pressure.		Ratio of (*b*) to (*a*).
		(*a*) On Single Model.	(*b*) On Parallel Models Ten Plate-widths apart.	
No. 1.	Feet.	Lb.	Lb.	
Full size . . .	5·94	0·01696	0·02268	1·34 to 1
Three-quarter size	5·94	0·00931	0·01257	1·35 to 1
Half size . . .	5·94	0·00401	0·00537	1·34 to 1

That the shielding-effect in lattice work is not dependent on the width of the plates alone is clearly shown in Table VII. (Appendix) and in *Fig. 11*, in which the results obtained from two pairs of models of the form No. 2, *Figs. 12*, are given. In this case the models were not similar, the external dimensions being the same, namely, 2·75 inches by 2·75 inches in each case, but the plates

being 0·125 inch wide in experiment A and 0·1875 inch in exper ment B. The ordinates of the curves show the ratio of the tot pressure on the parallel plates to the pressure on the single plat and, as will be seen, the divergence is considerable.

Pressure on Cylinders.—In the experiments on parallel plat it was observed that, for moderate distances apart, the intensity pressure on the leeward side of the front plate was practically tl same as the intensity of pressure on the windward side of the re

Fig. 11.



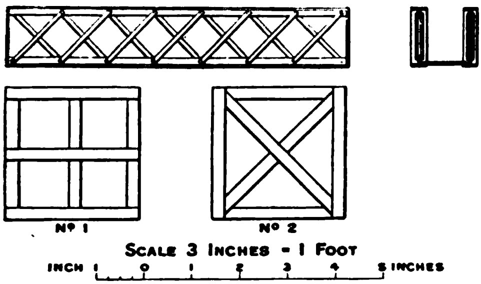
PRESSURES ON PAIRS OF DISSIMILAR LATTICE MODELS (MODEL NO. 2, *Fig. 1*

plate, *i.e.*, the air in the region between the two plates was at uniform pressure.

This suggested the conclusion that the total pressure on a sh cylinder would be nearly the same as that on a pair of parallel pla of the dimensions of its ends, and at a distance apart equal to t length of the cylinder. Experiments were made on a cylinder and a prism of square section, the lengths of which were varied, and t results, which are given in Table VIII. (Appendix), fully justifi

the above conclusion, the reduction in the resultant pressure being somewhat greater than in the case of the parallel plates. It will be seen from the figures in this Table that the changes in total pressure are very marked, as the length of the cylinder increases from 0·5 diameter to 1·5 diameter, after which the increase in the total pressure takes place at a much slower rate; thus for a cylinder whose length is 6 diameters, the resultant pressure is only 72 per cent. of that on a thin plate of the same diameter. In Table VIII. (Appendix) are also given the results of experiments on cylinders in series at varying distances apart. It will be seen that when the space between the cylinders exceeds half a diameter the resultant pressure is greatly increased, but that for spaces of one quarter of the diameter their effect is small.

Figs. 12.



LATTICE MODELS.

Normal Pressure on Inclined Plates.—As the apparatus used in these experiments appeared to be suitable for the determination of the pressure on inclined surfaces, a series of experiments was carried out on rectangular thin plates.

This subject has received considerable attention from Professor S. P. Langley[1] in his experiments at Washington. He, however, was chiefly concerned with the case of plates whose planes made small angles with the direction of the air-current. Mr. Dines[2] has also investigated this problem and has obtained curves of normal pressure for values of the inclination varying between 0° and 90°. It appears from Mr. Dines's experiments that when the angle between the direction of the current and the normal to the plate is about 45°, the normal pressure on the plate rises to a value considerably higher than its value for normal incidence of the current. This remarkable effect does not seem to have been

[1] "Experiments in Aerodynamics."

[2] Proceedings of the Royal Society, vol. xlviii.

noticed by Professor Langley, possibly because his experiments were mainly limited to values of the angle between 45° and 90°.

The following was the method adopted of obtaining the normal pressure on a plate in these experiments:—

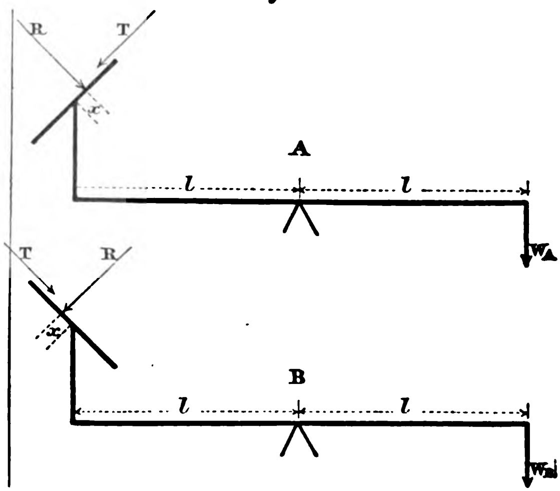
If, in the diagram (*Fig. 13*)—

R denote the normal pressure on the plate,
T the tangential pressure,
θ the angle between the direction of the current and the normal to the plate,
h height of the spindle carrying the plate,
l length of the arm of the lever,
x distance of the centre of pressure from the centre of the plate,
W_A and W_B the respective readings of the scale when balanced in the positions A and B,

Then—

$$W_A . l = R\,(l \cos\theta - h \sin\theta - x) + T\,(l \sin\theta + h \cos\theta) \quad (1)$$
$$W_B . l = R\,(l \cos\theta + h \sin\theta + x) + T\,(l \sin\theta - h \cos\theta) \quad (2)$$

Fig. 13.



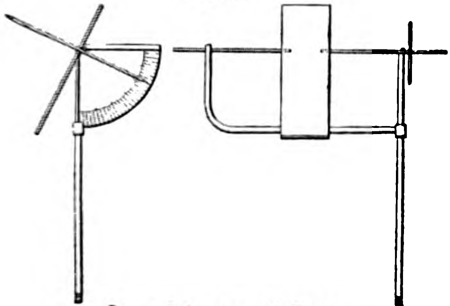
By an experimental determination of the value of x, the values of R and T may be obtained from (1) and (2), or neglecting T, as is done by Mr. Dines:—

$$R = \frac{W_A + W_B}{2 \cos\theta} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

In the experimental determination of the value of x the plate was mounted on a thin steel axle passing through its centre of

gravity and perpendicular to the direction of the currents, as shown in *Figs. 14*, the axle being free to rotate on the bearings with as little friction as possible. On setting up the air-current the plate took up a position inclined to the vertical at an angle

Figs. 14.



depending on the distance of its geometrical centre from the axis of rotation, *i.e.*, upon the value of x. Having determined a series of these angles corresponding to varying values of x, a curve of positions for the centre of pressure could be plotted.

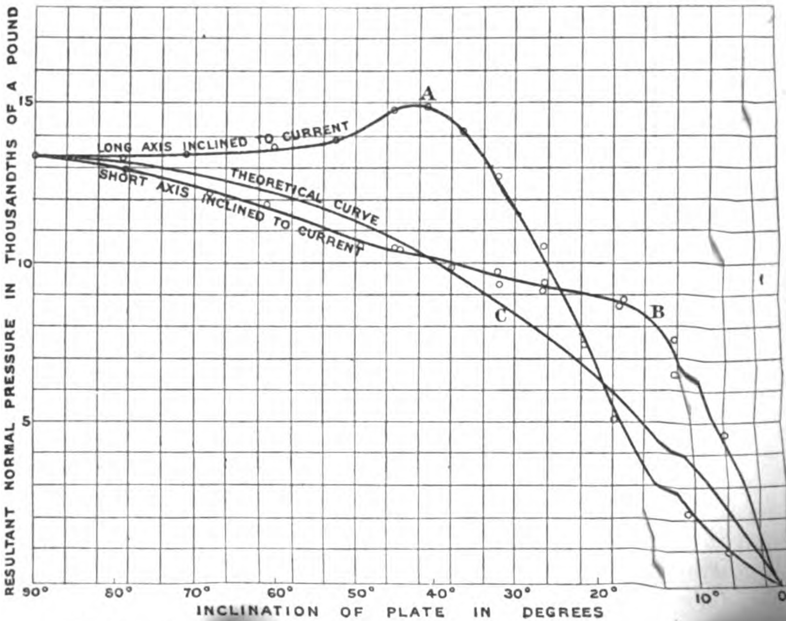
In the first experiments on inclined plates this curve was obtained and the values of R and T were found from equations (1) and (2). The value of T so determined was so small that it could be safely neglected except for values of θ greater than 65°, so that in the succeeding experiments the value of R was calculated from equation (3) for all angles up to 65°, equations (1) and (2) being used for the higher values. The results obtained from two plates, one 3 inches by 1 inch, placed so that its short side was at right-angles to the current, and one 3 inches by 1 inch placed with its long side perpendicular to the current, are given in Table IX. (Appendix), and are also plotted in *Fig. 15*, curve A referring to the former case, and curve B to the latter. Curve C is the theoretical case plotted from Lord Rayleigh's theory of the resistance of fluids,[1] in which the ratio of the normal pressure at any inclination to the normal pressure for perpendicular incidence R_0 is given by

$$R = R_0 \frac{(4+\pi)\sin\alpha}{4+\pi\sin\alpha}$$

[1] Scientific Papers, vol. i. p. 291.

where a is the inclination of the plane to the current $= (90 - \theta)$. It will be seen that, for the plate with its short axis perpendicular to the current, the normal pressure increases with the inclination reaching its highest value at approximately $\theta = 49°$, the curve in that respect resembling the one obtained by Mr. Dines in his experiments. When the long axis is placed perpendicular to the current a totally different effect is observed, the normal pressure

Fig. 15.



NORMAL PRES[illegible]RES ON PLATES 3 INCHES × 1 INCH INCLINED [illegible]
[illegible] DIRECTION OF CURRENT.

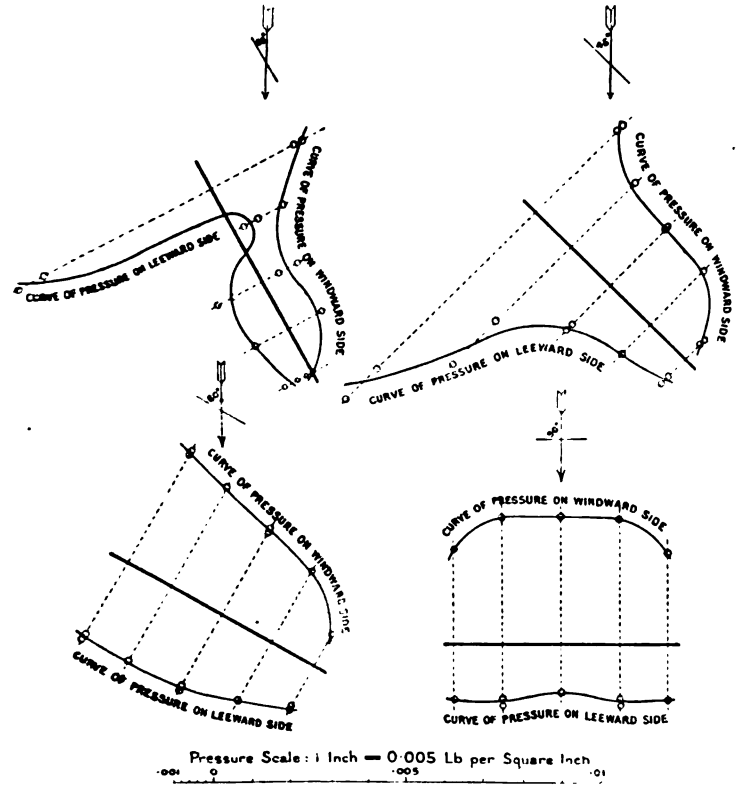
falling as the i[illegible]on is increased, the curve [illegible] values of the [illegible] compared with the oth[illegible] considerable in[illegible]s.

These obser[illegible] were repeated sever[illegible] same result. [illegible] considerable ex[illegible] in case B ov[illegible] case A for va[illegible] is in general [illegible]t with Pro[illegible]

[illegible]erimen[illegible]

In order to discover if possible the cause of the high values of the normal pressure attained in case A, observations were made on the intensity of pressure at various points of the plate at different inclinations. The curves of pressure thus obtained are shown in *Figs. 16*, from which it will be seen that the increase in the pressure on the leeward side of the plate is responsible for the increase in the result-

Figs. 16.



ant normal pressure. For values of θ greater than 45° the pressure on the leeward side is very unsteady, as indicated by the small circles in the diagram, which show the amount of the fluctuation.

In further observations on similar flat plates and similar lattice systems similarly inclined, it was found that the mean p—— remained independent of size. The models used in t— periments were the three sizes of the form No. 1, *Fig. 12*.

General Case of the Resultant Pressure on any System of Flat Surfaces.—Collecting the results given in the foregoing, the general conclusion to be drawn from the experiments is that, in all cases of similar combinations of flat surfaces similarly situated, the intensity of normal pressure at corresponding points is the same for the same velocity of current.

It would also appear, from a study of the distribution of pressure on the two sides of any thin plate in a current of air, that any attempt to express the results algebraically must involve the separation of the pressure on the windward side from that on the leeward side, in view of the fact that the maximum pressure on the windward side is solely dependent on the density and speed of the current, whereas the pressure on the leeward side is also a function of the form of the plate.

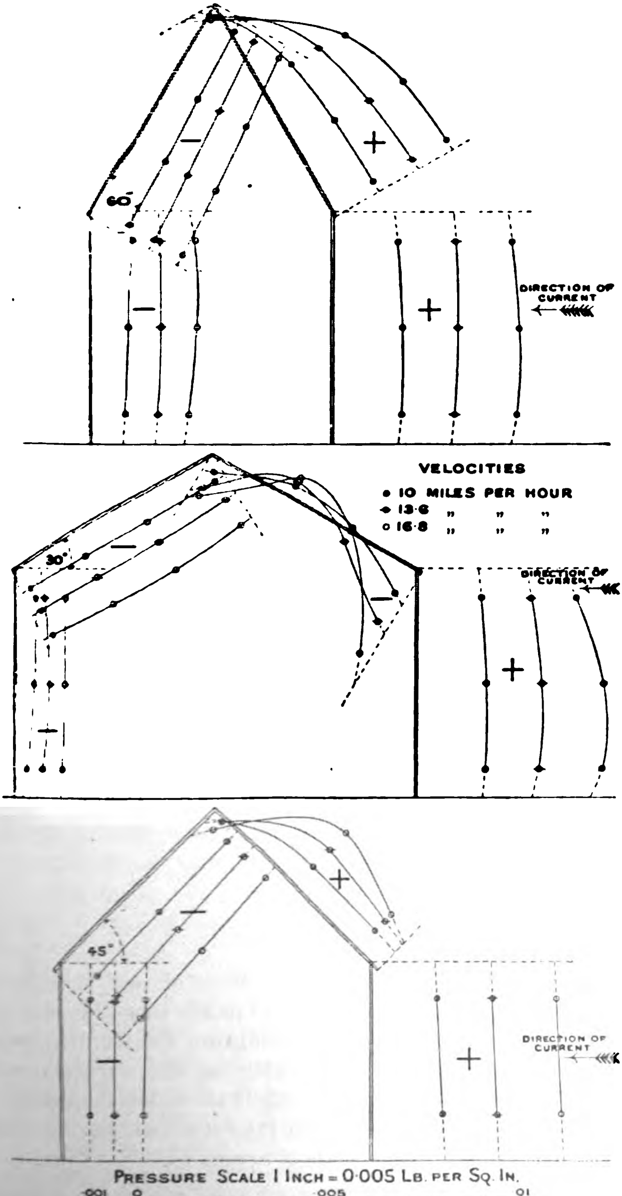
Experiments on Models of Structures.—From the foregoing conclusions it appears that the resistance of any structure in a uniform current of air may be predicted from experiments on models of the structure in an apparatus of the kind here described. As has been previously pointed out, the action of the wind is no doubt more complicated than that of a uniform current of air; yet it seems probable that in displacements of considerable intensity, such as gales, the conditions of a uniform current may be approximately fulfilled, so that the distribution of the wind-pressure on exposed structures may be regarded as that due to a uniform current. On this assumption a few typical cases have been experimentally treated as illustrations of a possible modification of the methods commonly used in estimating wind-pressures.

Experiments on Models of Roofs.—For this purpose the models illustrated in *Figs. 17* were prepared, as examples of rectangular buildings with roofs of simple form. Experiments on a model of this kind have been carried out and described by Mr. Irminger,[1] but as all these experiments were made on one model with a roof-angle of 45°, which was placed in a channel of comparatively small dimensions, it was considered desirable to make fuller observations on models of roofs of varying angles, the areas of which should not exceed 1 per cent. of the area of the channel.

The model was placed in the centre of the channel with a long strip attached to its base, which was set parallel to the current. The intensities of pressure were taken at points situated in a central section and are shown in the diagrams, in which are also

[1] Minutes of Proceedings Inst. C.E., vol. cxviii. p. 468, and *Engineering*, vol. lx. p. 787.

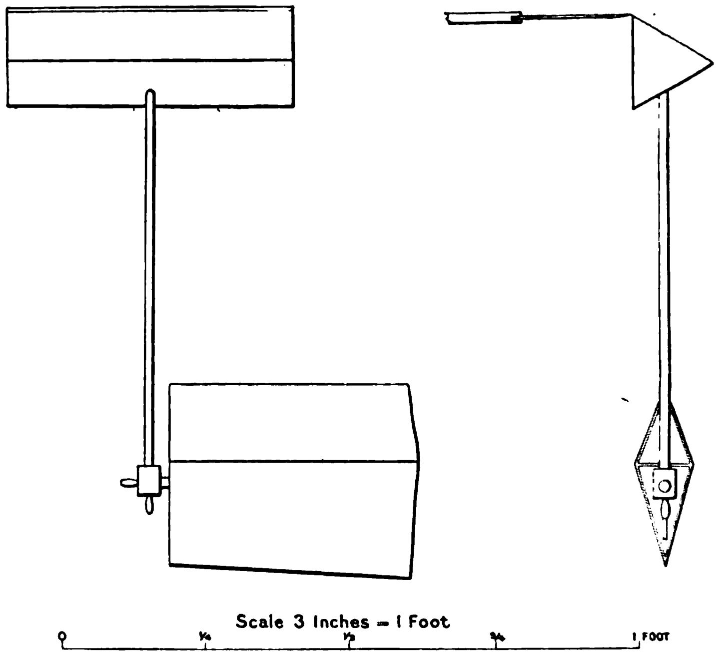
Figs. 17.



NORMAL PRESSURES ON ROOF MODELS.

plotted the curves of pressure for three speeds of current, positive pressures being plotted on the outside of the outline of the model and negative pressures on the inside. These pressures are also given in Table X. (Appendix). It will be noticed that in the case of the roof inclined at 30° the effect of the eddy from the windward wall is so considerable as practically to bring down the resultant pressure in the direction of the current to zero. As it was thought important to verify this, a roof-model of the form shown in *Fig. 18* was attached to the spindle of the lever, the edge of the

Figs. 18.



roof touching the edge of a fixed plate as shown, the fixed plate being intended for the purpose of producing the eddy due to the windward wall. The method of determining the resultant pressure was to balance the beam before turning on the current, and then to find the position of the jockey-weight at which the model moved away from the fixed plate under the action of the air-currents. The results obtained from models of angles of 30°, 45° and 60° are given in the following Table :—

Angle of Roof.	Dimensions of Side of Roof.	Velocity Head of Current.	Resultant Pressure in Direction of Wind.
Degrees.		Feet.	Lb.
60	3 inches by 1 inch	5·83	0·00804
45	" "	"	0·00514
30	" "	"	0·00160

This Table affords a check on the method of estimation employed in the previous cases. The experiments appear to indicate beyond question the importance of a consideration of the negative pressure on the leeward side of roofs.

Experiments on a Model of a Lattice Girder Bridge.—For this purpose the bridge-model shown in *Figs. 12* was prepared. Experiments were made on a single girder, and on two parallel girders with and without a roadway, normal and inclined to the direction of the current. From the results which are given in Table XI. (Appendix), it will be seen that the shielding effect of the windward girder is very considerable, for both normal and inclined currents. When the two girders are connected by a roadway and are at a distance apart equal to the depth of the girder, the pressure on the leeward girder is 15 per cent. of that on the windward girder; and at twice this distance the pressure is 25 per cent. of that on the windward girder. The effect of the roadway appears to diminish the total pressure on the girders. When the direction of the current is inclined to the plane of the girders the resultant normal pressure is increased for small angles of obliquity, but not to any great extent, the value of the normal pressure when the current makes an angle of 75° with the plane of the girder being approximately 5 per cent. greater than that for normal incidence.

The experiments on models of structures were not extended beyond this stage, as it was considered advisable to test the applicability of the methods by comparing the results already obtained with those derived from the experiments on larger plates and combinations of plates in the open air, which are now being commenced at the National Physical Laboratory.

In conclusion, the best thanks of the Author are due to Mr. C. Jakeman for his assistance in the early stages of the work, and to Mr. W. G. Duffield, B.A., B.Sc., who assisted in the final observations and prepared the drawings accompanying the Paper.

The Paper is accompanied by sixteen drawings from which the Figures in the text have been prepared; and by the following Appendix.

APPENDIX.

(*NOTE.—The pressures in the following Tables are expressed in terms of a un of $\frac{1}{100,000}$ lb.*)

Table I.—Distribution of Pressure on Plates.

Velocity head of current = 5·91 feet.

Circular Plates.

Diameter.	Distance of Pressure Hole from Centre.	Pressure per Sq. Inch. Windward Side.	Pressure per Sq. Inch. Leeward Side.
Inches.	Inches.		
1	0	+327	
,,	0·25	+320	−156
2	0	+331	
,,	0·50	+325	−161
,,	0·80	+251	−160
2½	0	+330	
,,	0·50	+330	−158
,,	0·75	+313	
,,	1·00	+256	−158
,,	1·125	+194	−158
,,	1·20	+79	−165

Square and Rectangular Plates.

Dimensions.	Distance of Pressure Hole from Centre.	Pressure per Sq. Inch. Windward Side.	Pressure per Sq. Inch. Leeward Side.
Inches.	Inches.		
3·54 × 3·54 central section	0	+326	
,,	0·75	+307	−186
,,	1·25	+281	
,,	1·57	+253	−186
,,	1·75	+47	−200
3·54 × 3·54 diagonal section	0	+326	
,,	1·06	+316	−186
,,	1·77	+257	
,,	2·22	+185	−186
,,	2·47	−63	−200
6·25 × 0·25 central section	0	+328	
,,	1·00	+328	−226
,,	2·00	+321	−220
,,	2·75	+316	−216
,,	3·07	+241	−274

TABLE II.—EXPERIMENTS ON CIRCULAR PLATES.

Diam. of Plate.	Velocity Head of Current.	Resultant Pressure.	Atmo. Pressure per Sq. In.	Temp. F.	Pressure per Sq.In. at 14·7 lbs. & 60° F.	Diam. of Plate.	Velocity Head of Current.	Resultant Pressure.	Atmo. Pressure per Sq. In.	Temp. F.	Pressure per Sq.In. at 14·7 lbs. & 60° F.
Ins.	Feet.		Lbs.	°		Ins.	Feet.		Lbs.	°	
2	0·762	145	14·50	64·8	47·3	2	5·31	990	14·56	61·0	319·5
,,	1·50	270	,,	,,	88·1	,,	8·80	1,625	,,	,,	526·0
,,	2·95	535	,,	,,	174·6	1½	0·99	108	14·80	67·0	61·7
,,	3·91	720	,,	,,	234·5	,,	3·10	334	,,	,,	191·0
,,	5·33	975	,,	,,	317·5	,,	5·42	569	,,	,,	325·0
,,	8·73	1,615	,,	,,	527·5	,,	8·60	912	,,	,,	522·0
,,	10·62	1,980	,,	,,	646·0	1	2·65	125	14·85	75·2	163·0
,,	12·85	2,405	,,	,,	785·0	,,	4·66	217	,,	,,	282·0
,,	0·933	175	14·90	62·2	55·3	,,	7·80	358	,,	,,	467·0
,,	1·64	305	,,	,,	96·5	,,	11·30	533	,,	,,	694·0
,,	2·74	505	,,	,,	159·5	½	2·83	32	14·70	66·8	166·0
,,	3·19	580	,,	,,	183·0	,,	5·00	57	,,	,,	294·0
,,	4·25	795	,,	,,	251·0	,,	6·88	85	14·52	63·0	441·0
,,	5·18	975	,,	,,	308·0	,,	8·31	96	14·70	66·8	493·0
,,	0·878	160	14·56	61·0	51·7	,,	11·92	141	,,	,,	724·0
,,	3·01	560	,,	,,	180·5						

TABLE III.—EXPERIMENTS ON SQUARE PLATES.

Side of Plate.	Velocity Head of Current.	Resultant Pressure.	Atmo. Pressure per Sq. In.	Temp. F.	Pressure per Sq. In. at 14·7 Lbs. at 60° F.	Side of Plate.	Velocity Head of Current.	Resultant Pressure.	Atmo. Pressure per Sq. In.	Temp. F.	Pressure per Sq. In. at 14·7 Lbs. at 60° F.
Inch.	Feet.		Lbs.			Inch.	Feet.		Lbs.		
1·77	0·72	136	14·60	62·6°	43·3	0·886	0·63	30	14·90	72·8°	39·4
,,	2·87	543	,,	,,	173·0	,,	2·29	108	,,	,,	140·0
,,	5·23	992	,,	,,	315·0	,,	4·71	218	,,	,,	283·0
,,	8·44	1,570	,,	,,	500·0	,,	7·90	363	,,	,,	472·0
,,	12·27	2,290	,,	,,	728·0	,,	11·45	528	,,	,,	686·0
1·33	1·01	96	14·90	72·8°	54·7	0·442	0·85	9	,,	,,	50·0
,,	2·44	266	,,	,,	152·0	,,	2·78	28	,,	,,	157·0
,,	4·94	530	,,	,,	302·0	,,	5·01	56	,,	,,	310·0
,,	8·38	888	,,	,,	506·0	,,	8·31	85	,,	,,	
,,	12·70	1,340	,,	,,	764·0	,,	11·91	125	,,	,,	

TABLE IV.—EXPERIMENTS ON RECTANGULAR PLATES.

Velocity of current = 21·4 feet per second.

Dimensions of Plate.	Ratio of Length to Width.	Resultant Pressure.[1]	Pressure[1] per Sq. In. at 14·7 Lbs. and 60° F.	Dimensions of Plate.	Ratio of Length to Width.	Resultant Pressure.[1]	Pres per S at 14· and 6
Inches. Inch.				Inches. Inch.			
1·77 × 1·77	1·0	1,275	423	4·5 × 0·30	15·0	653	5
3·0 × 1·0	3·0	1,227	426	6·0 × 0·30	20·0	935	5
3·75 × 0·75	5·0	1,157	430	7·5 × 0·30	25·0	1,222	5
2·5 × 0·50	5·0	526	438	9·0 × 0·30	30·0	1,526	5
1·25 × 0·25	5·0	130	435	6·0 × 0·15	40·0	542	6
3·0 × 0·30	10·0	411	477	7·5 × 0·15	50·0	693	6
5·0 × 0·50	10·0	1,150	480	9·0 × 0·15	60·0	862	6

TABLE V.—EXPERIMENTS ON LATTICE MODELS OF FORM No. 1, *Fig. 1*

Dimensions of Model.	Velocity Head of Current.	Resultant Pressure.[1]	Atmospheric Pressure per Sq. In.	Temperature Fahrenheit.	Pressure Sq. In 14·7 Lbs 60°
	Feet.		Lbs.		
2·75 inches by 2·75 inches (plates ½ inch wide)	2·66	703	14·50	61·5°	201
	4·69	1,280	,,	,,	36
	8·10	2,136	,,	,,	61
	12·05	3,177	,,	,,	90
2·06 inches by 2·06 inches (plates $\frac{3}{16}$ inch wide)	2·42	365	14·60	55·0°	18
	4·62	723	,,	,,	35
	7·35	1,129	,,	,,	56
	11·05	1,695	,,	,,	84
1·375 inch by 1·375 inch (plates ⅛ inch wide)	2·79	188	14·50	61·5°	21
	5·01	330	,,	,,	37
	8·34	546	,,	,,	62
	11·85	780	,,	,,	89

TABLE VI.—EXPERIMENTS ON PAIRS OF PARALLEL CIRCULAR PLATE AT VARYING DISTANCES APART.

Velocity of current = 24 feet per second.

Diameter of Plate.	Total Pressure.[1]	Distance apart in Diameters.	Diameter of Plate.	Total Pressure.[1]	Distance a Diamet
Inches.			Inches.		
2	1,622	0 (Single plate)	2	2,330	3·0
,,	1,670	0·17	,,	2,580	3·5
,,	1,665	0·35	,,	2,800	3·9
,,	1,597	0·50	1·5	921	0 (Single
,,	1,503	0·75	,,	873	0·
,,	1,338	1·00	,,	964	1·
,,	1,210	1·25	,,	850	2·
,,	1,204	1·50	,,	1,083	2·
,,	1,450	2·00	,,	1,497	3·
,,	1,960	2·50	,,	1,636	4·

[1] See note on p. 108.

TABLE VII.—EXPERIMENTS ON PAIRS OF DISSIMILAR LATTICE MODELS, No. 2, *Fig. 12*.

Velocity of current = 21 feet per second. Models 2·75 inches by 2·75 inches.

Width of Plates.	Total Pressure.[1]	Distance apart in Terms of Width of Plates.	Width of Plates.	Total Pressure.[1]	Distance apart in Terms of Width of Plates.
Inch.			Inch.		
$\frac{3}{16}$	1,780	0 (Single model)	$\frac{1}{8}$	1,250	0 (Single model)
„	1,760	1·0	„	1,246	1·0
„	1,640	2·0	„	1,191	2·0
„	1,730	4·0	„	1,517	4·0
„	2,082	6·6	„	1,796	8·0
„	2,392	10·6	„	1,988	16·0
„	2,640	16·0	„	2,068	24·0
„	2,803	24·0	„	2,145	40·0
„	2,970	37·3	„	2,160	70·0

TABLE VIII.—EXPERIMENTS ON CYLINDERS AND PRISMS OF VARYING LENGTH.

Velocity of current = 20·3 feet per second.

Dimensions.	Length.	No.	Total Pressure.[1]	Dimensions.	Length.	No.	Space between Cylinders.	Total Pressure.[1]
Inches.	Inches.			Inch.	Inches.		Inch.	
2·07 diam.	0·01	1	1,245	1·09 diam.	1·64	2	0·25	250
„ „	1·00	1	1,225	„ „	1·64	2	1·00	298
„ „	2·00	1	1,070	„ „	1·64	3	0·25	262
„ „	2·50	1	956	„ „	1·64	3	0·50	279
„ „	3·00	1	795	„ „	1·64	3	0·75	345
„ „	5·00	1	870	„ „	1·64	3	1·00	352
1·09 „	0·01	1	347	„ „	1·64	4	0·25	264
„ „	1·64	1	224	„ „	1·64	4	0·75	337
„ „	3·28	1	246	1·77×1·77	0·01	1	..	1,120
„ „	4·92	1	250	„ „	1·77	1	..	1,024
„ „	6·56	1	251	„ „	2·65	1	..	787

TABLE IX.—NORMAL PRESSURE ON INCLINED PLATES (3 INCHES × 1 INCH).

Velocity of current = 21 feet per second.

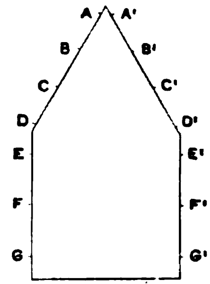
(*θ denotes the angle between the direction of the current and the normal to the plate.*)

θ.	Calculated Resultant Normal Pressure.[1]	θ.	Calculated Resultant Normal Pressure.[1]	θ.	Calculated Resultant Normal Pressure.[1]
Degrees.		Degrees.		Degrees.	
0	1,330	68·0	760	52·0	992
11·3	1,324	72·8	505	57·3	973
19·0	1,328	79·8	218	58·0	946
30·0	1,342	84·0	101	63·8	936
39·0	1,388	0	1,330	„	916
45·0	1,464	11·8	1,292	72·8	883
49·2	1,495	22·0	1,222	„	873
53·3	1,413	28·5	1,182	79·8	745
57·3	1,285	40·3	1,078	„	645
63·8	1,042	45·2	1,050	84·0	440

[1] See note on p. 108.

TABLE X.—DISTRIBUTION OF PRESSURE ON ROOF MODELS.

Pressure Holes.	Pressure[1] per Sq. In. at 10 Miles per Hour.	Pressure[1] per Sq. In. at 13·6 Miles per Hour.	Pressure[1] per Sq. In. at 16·8 Miles per Hour.	Pressure Holes.	Pressure[1] per Sq. In. at 10 Miles per Hour.	Pressure[1] per Sq. In. at 13·6 Miles per Hour.	Pressure[1] per Sq. In. at 16·8 Miles per Hour.
A	− 7	− 7	− 28	A¹	−78	−134	−208
B	+ 96	+179	+255	B¹	−85	−151	−226
C	+120	+219	+328	C¹	−94	−161	−240
D	+132	+248	+347	D¹	−96	−172	−250
E	+170	+316	+467	E¹	−99	−167	−257
F	+184	+325	+486	F¹	−94	−172	−264
G	+182	+318	+477	G¹	−87	−165	−245
A	− 40	− 89	−111	A¹	−73	−127	−203
B	+ 26	+ 38	+ 52	B¹	−80	−143	−224
C	+ 7	− 35	0	C¹	−78	−143	−222
D	− 80	−168	−260	D¹	−75	−137	−212
E	+168	+298	+415	E¹	−66	− 94	−152
F	+182	+328	+491	F¹	−61	−111	−152
G	+179	+321	+484	G¹	−42	− 89	−146



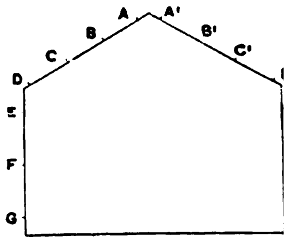


TABLE XI.—EXPERIMENTS ON LATTICE GIRDER BRIDGE MODELS.
Velocity of current = 20·4 feet per second.

Particulars of Model.	Inclination of Plane of Model to Direction of Current.	Resultant Pressure.[1]	Pressure per Sq. I at 14·7 Lbs. 60° F.
	Degrees.		
Single girder	90	1,890	484
„	75	1,925	494
„	60	1,822	468
Two girders 1·1 inch apart, no roadway .	90	2,435	624
Two girders 1·1 inch apart, with roadway	90	2,178	558
„ „ „	75	2,277	584
„ „ „	60	2,066	530
Two girders 2 inches apart, with roadway	90	2,365	607

[1] See note on p. 108.

Discussion.

The PRESIDENT, in moving a vote of thanks to the Author, said he was sure the members would welcome the Paper as the first contribution from the National Physical Laboratory recording researches made there which had a bearing upon engineering work; and it was very satisfactory to observe that the small-scale experiments, which had been conducted with great ability and with beautifully devised apparatus, were to be followed by large-scale experiments in the open air. The President.

The AUTHOR mentioned that, instead of preparing diagrams of the two instruments used in the research, he had placed the instruments themselves on the table, and would be glad to explain them after the meeting. The Author.

Dr. R. T. GLAZEBROOK, Director of the National Physical Laboratory, drew attention to two or three points connected with the experiments. He quite realized that experiments on small models were not to be taken as settling a great engineering problem; and the experiments which it was hoped to start at the Laboratory shortly would be a fitting continuation of the work described in the Paper. Already a windmill-tower 50 feet high had been erected, and models of the kind used by the Author were to be placed on the top of it; but instead of working with models 2 inches in diameter, the tower was planned on the supposition that the largest models would be 10 feet across. He trusted that in that way results would be obtained which would have a real engineering value. At the same time, he felt that already the Author's work had gone a long way to establish the proposition that it was possible by experiments on small models to infer what would be the behaviour of a structure in a wind. It appeared to him that the systematic character of the results showed that fairly correct inferences might be drawn from them; and that the fundamental fact which the Author had established, namely, that for similar models the resulting pressure was strictly proportional to the area, would prove in the end to be a true law. It was not altogether in accordance with previous experiments, but he thought when the matter came to be looked into it would be found that explanations might be given of the discrepancies which had hither been observed. One obvious cause of discrepancy was the fact in the open air there were gusts in the wind; and it might q Dr. Glazebrook

TABLE X.—DISTRIBUTION OF PRE[illegible]

Pressure Holes.	Pressure[1] per Sq. In. at 10 Miles per Hour.	13·6 Miles per Hour.	16·8 Miles per Hour.	Pressure Holes.	Pressure[1] per Sq. In. at 10 Miles per Hour.	13·6 Miles per Hour.	16·8 Miles per Hour.
A	− 7	− 7	− 28	A¹	−78	−134	[illegible]
B	+ 96	+179	+255	B¹	−85	−151	[illegible]
C	+120	+219	+328	C¹	−94	−161	[illegible]
D	+132	+248	+347	D¹	−96	−172	[illegible]
E	+170	+316	+467	E¹	−99	−167	[illegible]
F	+184	+325	+486	F¹	−94	−172	[illegible]
G	+182	+318	+477	G¹	−87	−165	[illegible]
A	− 40	− 89	−111	A¹	−73	−12[illegible]	[illegible]
B	+ 26	+ 38	+ 52	B¹	−80	−143	[illegible]
C	+ 7	− 35	0	C¹	−78	−143	[illegible]
D	− 80	−168	−260	D¹	−75	−13[illegible]	[illegible]
E	+168	+298	+415	E¹	−66	[illegible]	[illegible]
F	+182	+328	+491	F¹	−61	−1[illegible]	[illegible]
G	+179	+321	+484	G¹	−42	[illegible]	[illegible]

[illegible]LE XI.—EXPERIMENTS [illegible]
Velocity of curre[illegible]

[illegible]rs of Model.

Si[illegible]

[illegible]part, no[illegible]

[illegible]part, wi[illegible]

[illegible]rt, w[illegible]

[illegible] apparatus, exposed to one of [illegible] pressure than the average [illegible] apparatus. Another result of [illegible] of the coefficient connecting [illegible] of the current. A num- [illegible] had been found within recent [illegible] It was interesting and en- [illegible] the Author had found for it, [illegible] with the value found by Mr. Dines [illegible] a large scale, conducted in the [illegible] table, 56 feet in diameter. For [illegible] curve in *Fig. 15*, showing the in- [illegible] a certain case up to an angle of [illegible] by Mr. Dines's experiments. [illegible] that: on the leeward side of the [illegible] distribution of pressure was distinctly [illegible] manometer devised by the Author for [illegible] was an instrument which would [illegible] In conclusion, he wished to express [illegible] to the Institution for the great [illegible] had been given to it in the [illegible] given very kindly by distinguished [illegible] advising as to what line the experi- [illegible] valuable monetary help generously [illegible] enable the experiments to proceed. [illegible] were sincerely grateful for that [illegible] might be only the first of a series [illegible] science.

[illegible] agreed with Dr. Glazebrook that the [illegible] experiments on quite small models [illegible] made with full insight into the condi- [illegible] accuracy as had been obtained in [illegible] if quantitatively the results [illegible] the contemplated experiments on [illegible] any rate thrown a flood of light on [illegible] could be expected. In discussing the [illegible] seemed to be attached sometimes to the [illegible] motion of the air was a stream-line or an [illegible] was a reference to that point in the [illegible] discussions a kind of mystery had been [illegible] unnecessarily—on the ground that the [illegible] He was inclined [illegible] motion might be

regarded as an eddying motion superimposed on a mean stream-line motion; and that it might be considered that, the eddying motion being quite disorderly, it did not practically affect the results. All the experiments seemed to bear that out, because the results were what would be expected if the motion were a stream-line motion. It would be of advantage to some engineers if the Author would give a diagram of the points of the Pitot tube on rather a larger scale. A good deal of discussion had taken place about the best arrangement of the orifices in the Pitot tube, and a figure on a larger scale would be helpful to those who used that instrument. He was under the impression that the formula of Lord Rayleigh, plotted in *Fig. 14*, was an expression for the pressure on the front side only of a plate; and if that were so, it would account to some extent for the differences between the observed curve and the theoretical curve. As a point of some interest, he might mention a much earlier experiment in which that rise of the curve of normal pressure had been observed. As long ago as 1868 some experiments had been made for the Aëronautical Society by Mr. Wenham, on plates placed at various inclinations immediately in front of the blast from a very large foundry-fan, the apparatus having been arranged to measure the two rectangular components of pressure on the plate. Many years ago he had investigated the results, and had found that for angles of 45° and 60° the normal pressure was greater than the pressure on a plate placed normally to the current. The experiments on roofs were of great interest to engineers. Previously no very accurate calculations had been made of wind-pressure on roofs, and the Author's experiments showed conclusively that no distribution of the pressure on a roof which had been assumed hitherto was anything like the truth. It turned out that the greatest straining force which came on a roof of that type, especially if it was not very high-pitched, was the straining action on the leeward side. It would be interesting if the Author could make a few more experiments on those models, varying the relative heights of the wall and the roof, and perhaps also varying—for the result would probably be rather interesting—the inclination of the longitudinal axis of the building to the direction of the air-current. Prof. Unwin.

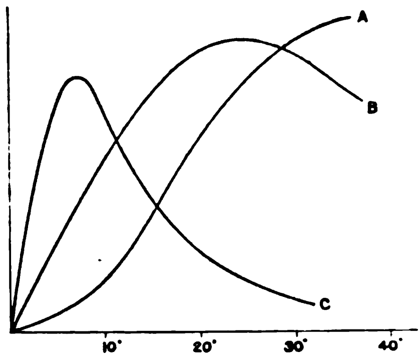
Mr. A. MALLOCK remarked that the Paper touched on a great variety of problems, some of which he had investigated on similar lines in the years 1896 and 1897; and such results as he then obtained were in entire agreement with those arrived at by the Author. He was glad to see experiments on small models coming to the front again; and he thought that if a true scale of comparison Mr. Mallock.

Mr. Mallock was secured, engineers need not fear to draw from them resul applicable to large things: in fact, it would rather have to be ex plained why the experiments should not agree, than why the should. Using a larger rectangle and a larger disk than th Author, he had found that within a very small distance of the edg there was even greater negative pressure on the lee side tha was indicated by *Figs.* 7 (p. 90). He had found a negativ pressure equal to 2½ times the dynamic head in front of the plat with a 10-inch disk and the hole of the anemometer less than $\frac{1}{1}$ inch from its edge. The general distribution of negative pressu was exceedingly interesting, more so than that of the positiv pressure, which followed the well-known stream-line law Negative pressure, however, was due to the formation of eddie which at present was rather a mysterious subject, and required good deal of investigation. The eddies formed on the lee side the plate were not like the mathematician's vortex-rings, in whic each closed circuit had a potential, but were a mixture, half bein air from the front side of the plate, and half air drawn fro behind it. In certain conditions, supposing the current of a impinged normally on a thin plate which was long compared wi its width, a small eddy was first formed behind one edge, air bein drawn in from the back of the plate, and mixed with air from t front, to form an eddy, which grew until it practically filled t whole of the space behind the plate. That eddy then broke aw and drifted in the wake, while another eddy, rotating in the opposi direction, began to form at the opposite edge of the plate. T formation of the eddies occupied a certain definite period of tim *e.g.*, one complete eddy might be formed in the time which the flu took to flow 2½ diameters of the plate, and during that time t eddy would be gradually increasing. That process was repeat time after time, a series of left-handed and right-handed eddies bei formed, which drifted away in the wake. In other conditions t eddies were formed simultaneously at each edge. He had vestigated some of the properties of eddies by allowing a thin bea of light to fall intermittently on the eddies as they were bei formed, the motion of the air being rendered visible by feeding a stream of smoke on the windward side. The frequency of t illumination having been very slightly different from the rate formation of the eddies, a fresh eddy had been shown in slightly different state at each illumination, and thus it had be possible to see the growth of eddies.

The Pres. - The PRESIDENT asked whether any fluctuations of pressure h to 1 observed.

Mr. Mallock said the process of formation was too rapid, but there must be an alteration of the pressure. The same sort of thing happened in the Æolian harp. The formation of the eddy slightly altered the direction of the flow on the up-stream side, and there was resultant pressure normal to the general current. The string was thereby deflected, and the time of the vibration of the string settled the rate of formation of the eddies and whether they were right-handed or left-handed. An example of the same effect could often be seen in a bough sticking up in a stream and wagging in the current. That happened when the natural period of the bough itself was equal to the period in which eddies would naturally be formed, which was equal to the time taken by the stream to flow about $2\frac{1}{2}$ diameters of the vibrating stick itself. With regard to *Fig. 15*, he had made some experiments on the pressure on plates nearly parallel to the direction of flow, the quantities measured being the pressure in the direction of the stream and the pressure normal to the stream—not that normal to the plate. The curves were of the kind shown in *Fig. 19*. The curve showing the ratio between the two pressures—which was the quantity that had to be taken into account in flying and sailing—rose rapidly to a maximum at about $4\frac{1}{2}°$. Those experiments he had tried in air, and Mr. R. E. Froude had tried them in water; and the two results were exactly comparable, taking into account the different densities of the two fluids. Mr. Mallock.

Fig. 19.



A Pressure in direction of stream.
B Pressure normal to direction of stream.
$C = \frac{B}{A}$

Mr. Alexander Siemens mentioned that a remarkable result, which to a certain extent bore out the explanations of Mr. Mallock, had been obtained from experiments carried out upon the two high-speed electric railway carriages which recently ran at about 210 kilometres (about 130 miles) per hour near Berlin; and although, owing to the "Studiengesellschaft" not having yet published their report, he was not at liberty to give figures, he mig Mr. Siemens.

Mr. Siemens. explain the nature of the result. Various forms had been tried for the front and rear of the carriages, *e.g.*, triangular and semi-circular in plan. It appeared that, behind the moving carriage, there was a space, triangular in plan, in which the barometric pressure of the air was exactly the same as inside the carriage. The air-pressure had been measured by fixing tubes in the front and back walls of the carriages, and connecting them to U water-gauges. Large tubes had also been thrust out from the inside of the carriage forward, in order to explore the air in front of the carriage; with the result that in the triangular space there had been found to be practically the same pressure as near the front of the carriage, while at the sides there was no pressure. Further proof of this phenomenon was afforded by the fact that accidentally one of the glass plates at the side had been smashed by striking a bird when the carriage was going at nearly 200 kilometres per hour, and instead of the air rushing in it had rushed out. Evidently the action of the air rushing past the carriage set up such a strong suction that the air came out of the carriage instead of going inside. The results would be published in detail by the "Studiengesellschaft," and his only reason for referring to them was to call attention to the extraordinary fact that there was a region of about normal barometric pressure travelling behind a vehicle running at such a speed.

Sir Benjamin Baker. Sir BENJAMIN BAKER, K.C.B., Past-President, remarked that, although he first studied the question of wind-pressure more than 20 years ago, he had sought in vain during that period for exact information such as that brought before the Institution by the Author; and he thought the staff of the National Physical Laboratory were to be congratulated on the valuable work with which they had initiated their duties. He did not think there was a single word in the Paper to which he could take exception. He quite believed in the immense value of the results which could be obtained—in some cases with very little trouble, but with infinite trouble in the present instance—from small models. Of course, engineers had often to deal with problems which were very different from laboratory experiments; they had to pronounce whether a structure was or was not safe as it stood—to take the responsibility of saying that it was safe, or that it must be reconstructed, possibly at heavy expense. Frequently, if the engineer were guided solely by the results of laboratory experiments he would decline to take that responsibility, and would say that the structure must be rebuilt; and yet sometimes he was reassured by finding that there were hundreds of structures, even weaker than the one under

Sir Benjamin Baker.

his consideration, which had stood unquestioned for many years. In the case of wind-pressure, on taking up the subject in the year 1880, he had not only initiated experiments on models, but had also carefully noted numerous buildings which were standing, and had compared their calculated stability with the forces indicated by small pressure-plates, with startling results. Houses had windows all over the world, and it was not a matter of common occurrence, even during a very high gale, for windows to be smashed in. He had started by determining the strength of ordinary windows of different kinds. This he did by putting ledges round the windows laid flat and filling the tanks so formed with water until they broke: thus obtaining a constant from which it was possible to calculate, with a high degree of accuracy, the strength of any window, having regard to the sashes, mouldings, tenons, and glass, and the strain put on the glass when the sash-bars were deflected. He found that ordinary windows would stand a pressure of about 30 lbs. per square foot; some were much stronger and some much weaker. That, of course, was front pressure, and in considering wind-pressure it was necessary to add the leeward pressure; but allowing for the reduced strength of old wood which perhaps had been standing 50 years or more, it was probable that a 30-lb. wind would smash such windows. Old stained-glass windows in cathedrals were weaker than the ordinary windows of houses, on account of the lead framing; in fact, as far as he could judge, they were very weak. Some, such as at Tewkesbury Abbey, had been blown in; yet a great many of them had been standing in exposed positions for hundreds of years. Again, engineers in the old days thought nothing of putting up cast-iron arch bridges of 80 feet span without any cross bracing, and with arch ribs about 10 inches in flange width as their sole source of strength to resist wind-pressure. Undoubtedly the Author's experiments represented with accuracy the distribution of wind-pressure on a small scale; and he believed with Dr. Glazebrook that on a larger scale they would represent the actual state of affairs, if wind-pressure were uniform. They threw a large amount of light on matters in connection with roofs which hitherto had been altogether obscure to practical engineers. They had gained by experience a general idea as to what a roof would stand, and what it would not stand—a kind of rule of thumb; but certainly so far he had never seen on a diagram anything which threw so much light on the action of wind on roofs as was contained in the Paper. The discrepancy between the actual pressure on structures and the pressure indicated over small areas was, he thought, due to the fact that in practice

Sir Benjamin Baker. engineers had not to deal with uniform currents but with velocities varying widely within small distances at the same instant of time, and he might illustrate the effect of that in the following way:— If two men took hold of the ends of a rope and pulled against each other, they put a certain stress on the rope; but if a hundred men were engaged in a tug-of-war they would not put a hundred times that stress on the rope, nor anything like it, unless, like blue-jackets and gunners, they had been carefully trained to pull all together. He thought that was a real analogy of the difference between small models in uniform currents and big structures in winds. In a gale there was a vast number of swirls of air which, if they could only be trained to pull together, might make the pressure per square foot on a large surface as great as on a small one; but as a matter of fact they did not pull together, and he did not think they did more than perhaps two-thirds of the work they would do if they could be trained. It was not a fallacy in the experiments or in the theory, but simply that practical point, that in a gale of wind the air, like the water in a river, did not flow uniformly. Experiments on the flow of rivers showed that if a row of floats were put across a river they did not advance altogether according to the theoretical curve of velocities, with the maximum velocity at the centre, but, apparently for no reason whatever, the relative velocity of two neighbouring floats varied from moment to moment; first one float would gain on the other and then the second float would overtake the first, and so on; they did not all travel at their best speed together. Any boating man who had tried on the river to see whose sailing-skiff would arrive first at a lock would no doubt have noticed that sometimes he gained on his neighbour, and sometimes his neighbour gained on him, when they were sailing side by side. It was the same in gales; there was not the uniformity of motion which was obtained in experiments in the laboratory. In practice the irregularities did not affect a small wind-gauge, but they undoubtedly did have an effect if the wind-gauge was large enough. That could be shown from the lateral deflection of bridges. From the pressure on the small wind-gauges it was easy to calculate what the lateral deflection of a bridge ought to be; but that lateral deflection did not occur, and therefore there could not be the same intensity of pre[illegible]he whole structure. He was glad to hear that lar[illegible]as to be put up, but the results so obtained wo[illegible]tract from the value of the Author's present ex[illegible], he doubted whether the next ex-eriment[illegible]uch value as those already made,

because as far as they went the latter were entirely free from all the disturbances he had referred to. The experiments showed the results which would be obtained if a gale of wind behaved like the air in the tube. In saying that, he did not mean in the least to suggest that the experiments were not of great practical value; indeed he could not sufficiently express his appreciation of and his thanks for the work done in the National Physical Laboratory. Sir Benjamin Baker.

Dr. ALEX. B. W. KENNEDY, Vice-President, asked the Author to give a diagram explaining the method of measuring the intensity of the air-pressure at different points on the surface of the plate. It might be clear as it stood to any one who understood the apparatus, but it was not clear to those looking at it for the first time. Professor Unwin might well have mentioned that he had not only worked out the unexpected fact of the excess of normal pressure on an inclined surface, but had published it in detail, and it had remained the only real theoretical statement on the matter. All who had worked at the subject knew quite well the value of this work of Professor Unwin, and it was exceedingly interesting to see experimental corroboration of calculated results given by him so long ago. Dr. Kennedy.

Sir JOHN WOLFE BARRY, K.C.B., Past-President, thought the members would congratulate themselves on having at last a National Physical Laboratory, where research could be undertaken, and where problems of the kind under discussion could be investigated with the skill and care which had been exercised in the Author's investigations. The Paper appeared to be the first ever laid before the Institution in which the subject of wind-pressure was approached from so scientific a point of view, and with such delicate and careful measurements. At the same time, he agreed with every word that had fallen from Sir Benjamin Baker, in regard to the practical application of the results. In practice it was very difficult to know what was the effect of the filaments of air, in regard to variation of the pressure and to its distribution over large areas. From that point of view it was interesting to learn that the experiments were to be extended by investigating the pressure over larger areas. He also agreed with Sir Benjamin in thinking that possibly not much information of a practical nature would be gained for the engineering profession, even from experiments of the size contemplated; because he could not help feeling that there were some causes at work which in fact reduced the mean pressure of wind upon the far larger areas with whi[ch] engineers had to deal. What those causes were it was v[ery] Sir John Wolfe Barry.

Sir John Wolfe Barry. difficult to say. The explanation might perhaps be found in th theory of the filaments of air being at different pressures, so tha the mean pressure was less than the pressure measured in a sma current; but whether that was the true explanation or not, h thought the fact remained that there must be some reduction fro the highest pressures recorded in various instances on small gauge to account for structures withstanding the wind in the way that the did. He well recollected, when driving through Scotland on th morning after the great gale which destroyed the Tay Bridg seeing narrow lanes blown through large woods—trees of the sam size, and apparently planted in the same soil, destroyed in straight line, and the trees on each side of the avenue standin quite uninjured. That might be due to a difference of pressure i a direct line, or it might be due to some action of an eddyin nature such as that alluded to by Mr. Mallock, resulting in cyclon action added to the velocity of translation of the gener current of the wind. At all events, the fact remained th frequently a large difference of pressure was observed in spo which were at comparatively small distances apart. He ha given some study to the difference of pressure on the two leav of the Tower Bridge. Those leaves practically constituted a win gauge about 100 feet long and 50 feet wide, and they we moved, of course, sometimes with the wind, sometimes again it. He had taken measurements of the pressure on each side of th leaves, and of the pressure of the wind at the upper part of th bridge and at the lower part; and by means of carefully-devise pressure-gauges in the hydraulic engine-houses he had been ab to find out what was the power exerted, respectively, when the wi was in favour of and when it was against the movement of one of th leaves. The results had shown clearly that the mean of th measurements of the wind-pressure at the top of the bridge and the level of the roadway, made with small gauges, were not i agreement with the mean pressure of the wind upon the leaves the bridge. He had always thought that one of the chief thin to be laid before the National Physical Laboratory when it w instituted was the determination of problems of this kind; a while he admired the experiments that had been made, he hop they would be repeated on even a larger scale than had bee proposed. He felt sure that if the Author could give his tim to investigation of the matter at the Tower Bridge, the Corpor tion of London would place the bridge at his disposal for th purpose. It was a matter of the utmost importance to enginee to know what were the strains and stresses due to wind whic

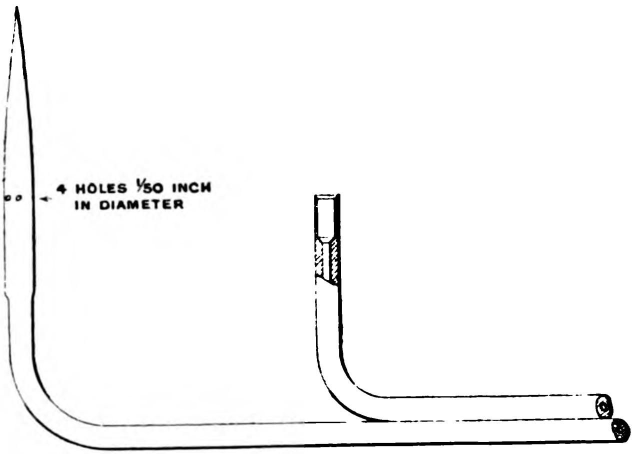
ought to be provided for in large structures. Air-resistance was also an important matter in connection with vehicles such as the high-speed carriages alluded to by Mr. Siemens. Probably many members had seen that on the Paris-Lyons-Mediterranean Railway what might be termed "cut-airs" had been put in front of the engine and at the rear of the train, and the spaces between the carriages had been filled. He had never heard whether that had had any measurable effect, but the Company continued the practice. The whole subject was one of such great interest to the profession, that the Institution might say that it had already received some value for the money contributed to the National Physical Laboratory, and might cordially wish the staff success and more funds for investigation. Sir John Wolfe Barry.

Colonel R. E. B. CROMPTON, C.B., remarked that he had done a good deal of experimenting of the kind for the Government during the last 2 or 3 years, for other purposes, and he had experienced some of the difficulties alluded to by other speakers in getting uniform currents of air. His experiments related to air-condensing apparatus, and he had had to ascertain the total quantity of air that would pass through channels in a given time to condense certain quantities of steam. The question of the two plates placed one behind the other was one which required very careful investigation in connection with the use of currents of air for cooling purposes or for condensers; and he hoped that in future experiments special attention would be given to that point, so as to show the absolute uselessness of more than two rows of tubes placed one behind the other. To some, the words "velocity head of current in feet of air" in the Table might be perfectly clear, but to him they were not so. He presumed this did not mean velocity, but something that was a measurement proportional to the square of the velocity, otherwise there would not be the straight line in *Fig. 8*, which showed a resultant intensity of pressure varying as the velocity, not as its square. Colonel Crompton.

The AUTHOR, in reply, gave an illustration on a larger scale of the form of Pitot tube and static-pressure tube used in the experiments (*Fig. 20*). He had tried several forms, and the conical perforated tube appeared to give the nearest approximation to the static pressure of the current, which was by far the more difficult of the two pressures to estimate. In reading various papers on the subject, in which the Pitot-tube method of measuring the velocity was described, he had found a great deal of ambiguity in the methods of determining the static pressure. The errors were due to the formation of eddies, a The Author.

The Author. to reduction of pressure consequent on contraction of flow; and h thought that these were eliminated in the arrangement illustrate With regard to *Fig. 15*, Lord Rayleigh's formula was applicabl as Professor Unwin had pointed out, to the pressure on the win ward side only, the pressure on the leeward side being neglecte The curve plotted from the formula was shown simply to indica the manner of variation of pressure with inclination in the thr cases. The initial ordinate of the curve was not any actual val obtained from Lord Rayleigh's formula. He hoped to be able make experiments, as suggested by Professor Unwin, on ro

Fig. 20.



NATURAL SIZE.

models, with a varying height of wall and at different inclinatio Mr. Mallock's description of the eddies at the leeward side of t plate was extremely interesting. The process of the formation these eddies could not have been detected in the present experimen by the fluctuations in the resultant pressure, on account of t dash-pot, which effectually damped variations of so short a peric The fact that he had not observed such a high intensity of negati pressure as Mr. Mallock had done was doubtless owing to t position of his pressure-holes, which in no case were near to the edge than 0·02 inch. He fully agreed with Sir Benjam Baker's view that in winds the filaments of air moved at ve different speeds, the effect of which would be that the me pressure on a large plate would be in many instances much l

than that on a small one. He had found a similar effect to occur The Author. to a considerable extent in the initial form of his apparatus, and it had only been by distributing layers of gauze at different parts of the channel that approximately uniform motion had been obtained across the tube. *Fig. 21* was the diagram asked for by Dr. Kennedy, showing how the intensity of pressure was actually measured. The lever carrying the pressure-plates was made hollow, and any particular point in the plate could be connected to the end of it. The air-pressure was transmitted through the lever, and at the knife-edge a flexible connection was made to the tilting gauge. The other arm of the tilting gauge was connected to the static-pressure tube in the current. With regard to Colonel Crompton's question, what he had termed the "velocity head" of the current was the difference between the pressure in the Pitot tube and the pressure in the static-pressure tube, *i.e.*, it was the pressure due to the velocity of the current. This pressure which was originally measured in inches of water on the tilting gauge was reduced to feet of air at the temperature and static pressure of the air in the current. It was this value which he had used in plotting the results in *Fig. 8*, and which was substituted for h in the formula $v = k\sqrt{2gh}$, to determine the velocity of the current.

Fig. 21.

HALF FULL SIZE.

The PRESIDENT heartily endorsed what had been said, especially The President. by Sir Benjamin Baker and Sir John Wolfe Barry, as to the high value of the experiments. The matter of air-pressure greatly interested all naval architects, and had interested them from the earliest times, in connection with the propulsion of ships by sails. Most of the earlier experiments had been made in connection with the propulsion of ships, and with a view to obtain an estimate the heel of ships under sail, or their speed under sail. Nearl years ago he had been led to take the matter up, and to make

The President. most thorough investigation possible of the records extant: their incompleteness and discord had induced him to apply to Mr. William Froude, to see if he could give any more exact and scientific information. Mr. Froude had already done a great deal in connection with the "Greyhound" experiments on air-resistance, and when applied to he had made, in the experimental tank, experiments leading to the formula which, in the Paper, was quoted as given on the President's authority in the third edition of his book on Naval Architecture, published in 1894. As a matter of fact, these experiments were made about 27 years ago, by moving a flat plate through still air at an absolutely uniform speed. He was still of opinion that Mr. Froude's results were, on the whole, the most trustworthy; they also approached very closely to the mean of Langley's observations. Many years ago he had also gone into Mr. Dines's experiments and had been interested in the curious curve given by Mr. Dines, and, at an earlier date, by Professor Unwin; and he had asked Mr. Edmund Froude to check in water the point to which Mr. Mallock had referred. Although Mr. Edmund Froude did not anticipate that the same phenomenon would occur in water, it did occur. To the President the great beauty of the Paper was to be found in the fact that, with disks so small as 2 inches in diameter, such systematic results as the variation of pressure from the edge towards the centre of the disk, and the phenomenon of the back pressure as compared with the front pressure, had been traced out and measured in a way that could only have given such strikingly uniform and obviously correct results by remarkable skill in the devising of the apparatus, and in its use. It was a wonderful piece of experimental apparatus; but he hoped nevertheless that the scale would be considerably increased, and the experiments be repeated. Then, with his unique experience of small-scale work, the Author would probably add greatly to the information he had given that evening.

Correspondence.

Mr. R. E. Froude considered the Paper and the results it gave to be of extreme interest, and the methods of experiment described seemed to him to be, in the main and for the purpose in view, quite beyond criticism. But among the results he noticed two items which struck him as being paradoxical, though this paradoxical character was not noticed in the Paper. The first of these was the conformation of the successive lines of equal pressure on the windward side of the square plate, namely, A, B, C, in *Fig. 7.* These became less circular and more sharply square as they were followed from the edges towards the centre. Off-hand, he would certainly have expected the change to be in the opposite direction. The second result he referred to, while it had more immediate practical importance, seemed even more startlingly paradoxical, namely, the increase in the pressure coefficient of a rectangular plate with increase in ratio of length to width, which was represented in Table IV. and *Fig. 9* as continuing with little abatement up to lengths equal to forty or fifty times the width and more. The increase in the pressure-coefficient could arise only from a change in the character of flow from a tri-dimensional towards a bi-dimensional type, and the pressure-change should follow the flow-change *pari passu.* But it was manifest that the flow-change must be incomparably, greater in passing, say, from one to five times, than from five to ten times the width; while beyond that the change throughout the greater part of the length of the plate must be scarcely sensible. But, according to the Paper, while the first change, to five times the width, increased the coefficient by only $2\frac{1}{2}$ per cent., the second increased it, for the entire area, by 10 per cent.; while the further successive changes to fifteen, twenty and twenty-five times the width, made successive additions which totalled up to a further 19 per cent. on the coefficient for the entire plate. This result seemed to him to be frankly incredible. It also seemed incompatible with the distribution of pressure along a 25-width rectangle, as indicated in *Fig. 7.* The results for the plate in an oblique current, exhibited in *Fig. 15*, were most interesting to him, by way of comparison with the results of experiments made in the Haslar experiment-tank a few years ago, on plates moving obliquely in water. For the same proportions of plate, these results accorded remarkably with those given in the Paper for air. Mr. Froude.

Mr. Froude. These Haslar experiments included several proportions of plate—each tried with the long axis both ways—between the extremes of 1·0 and 4·0; and it was worth noting that while, in respect of the portion of the curve from 0 to, say, 15° of a, there was a fairly uniform change in the curve with change in proportion, yet, in respect of the position of the maximum point and the other prominent characteristics of the diagram between 15° and 90°, the entire change occurred almost suddenly between the proportions of 1·25 and 1·5, with the long axis transverse to the line of motion.

Mr. Gale. Mr. C. H. Gale observed that if the form of the vanes of the Author's air-meter was as described in the Paper, the vanes would have varying pressure on different portions of their surface, if placed in a uniform current of air; and the motion of the air relative to the vanes could never be tangential to the vanes all over the surface at the same time, whatever the speed of rotation of the meter-spindle and arms. Vanes of that form (except they were very narrow) could not be expected to give a very accurate mean, seeing that the pressures at the one end of the vanes were so much in excess of those at the other (*Fig. 16*, plate inclined 45°). The pitch should be constant at all radial distances from the axis A, instead of proportional to the radii, and the vanes should be portions of an ordinary square-thread screw, in which the pitch was constant at all portions of the surface of the thread. The inclination of the vanes should be 45° at that radial distance from the axis A which was used in the calculation to determine the circumferential speed V of the vanes for a given velocity of rotation about the axis: the inclination of the vanes being steeper for portions of the vanes nearer the axis of rotation. *Figs. 17* possessed peculiar interest, because they would perhaps explain the partial destruction of a row of houses in Hong Kong during a typhoon in October, 1894, in which the greater portion of the fronts of a row of eleven houses was blown outward into the street. The cross section of the houses was very similar to the centre diagram of *Figs. 17*, in which the roof had a slope of 30°. The houses were two-storied, and the brickwork not of a very high class; and, in these circumstances, the tie effect of the party walls would not do much to resist the outward thrust of the air in the houses when a partial vacuum was formed outside. Almost instantaneous gusts of wind were experienced in the streets of Hong Kong during the course of a typhoon, and it was quite conceivable, in view of the results obtained by the Author, that the pressures on the inside and the outside of the house could vary to a sufficient extent to blow out the front wall, as almost

every opening in the houses was closed by the inhabitants during these violent gales, and the difference of pressure inside and outside might get no opportunity of adjusting itself before the walls gave way. The party walls, floors and roofs, had been left intact. There were no ceilings, and the tiles weighed, when wet, 34 lbs. per square foot, and were held in place simply by gravity, no spikes or nails being used, on laths 9 inches apart, supported on China-fir poles resting on the party walls. The wind had changed from the front of the house to the back during the course of the typhoon, and it was during the latter half that the destruction had taken place. The houses had an open space behind, and the width of the street in front was about 50 feet, with houses of equal height to those damaged on the other side of the road. An obvious precaution to take in typhoons would be to keep some door or window open on the lee side of the house, and to be ready to close it when the wind got round to that side. Mr. Gale.

Professor J. Gaudard, of Lausanne, considered that the Author's ingenious and delicate tests would throw some light on the pressures exerted by the air and its movements against structures, and would modify the views of engineers on several points. On meeting an obstacle the fluid developed reactions, in virtue of which it was reflected and flew on all sides according to the directions of least resistance. It did not cease to be continuous, but acquired instantaneously and continually changing density, which produced whirlwinds. These were propagated at a distance by virtue of the excessive mobility of the particles. It was a question therefore of phenomena of extreme complexity, upon which only direct and multiplied observations could furnish useful information. The theoretical considerations only served as guides for the carrying out of experimental researches. Thus observation showed that in an even current the average pressure exerted on small surfaces was constant, because the air could fly laterally along the sides, but wind striking an indefinite wall was bound to be reflected normally by producing a counter current of reaction and occupying space, a double reason why the direct afflux or the pressure diminished. It would thus at least be in a state of permanent uniformity; but nothing was less permanent than the action of the wind, which blew in intermittent squalls. The blow struck might be violent and irregular, but it was well to consider the maximum in a question of stability, although it might be followed by a calm due to the reaction of the air in rebounding. Nevertheless, an observation of precision should always be sought in order to simplify the questions, Prof. Gaudard.

Prof. Gaudard. and it was with good reason that the Author had first of made observations with regular currents and uniform conditi In order to investigate the effect of a direct or normal reflect he should ascertain to what pressure the bottom of a cylin open on the windward side would be submitted, and this various lengths; for, on the one hand, the greater length the better would the normal reflection be assured; on the other hand, the cylindrical envelope would exerci perturbing friction. Under these conditions it could be un stood that the afflux would concentrate itself towards the a and the reflux, a little weakened, on the perimeter; unlike case of an indefinite wall, where there would be nothing mutual friction, everywhere the same, of threads of air ente and leaving, which enabled a state of uniform and homogen equilibrium to be conceived if not realized. In regard to r the Author had rightly examined the effect of the vertical wa the building, contrary to the usual practice of engineers, wh the hypothesis of a stable wall, considered only the geomet block of air striking the roofing directly, and neglected the pressure or negative pressure on the opposite side. Thus, roo at 30° inclination was even found to experience negative press on account of the current repelled by the wall, which, in de of egress at the ground line, turned upward, repelling the d afflux of air and forcing it to glide in the direction of the slope. On the other hand, the roofing at 60° remained exposed, the air being reflected more normally. It might be however, that the roof must resist the first shock before it c experience the effect of the counter currents. It was ther possible that the hypothesis of engineers might not be quit justified; but it was wrong to omit to take account of the neg pressures on the opposite side, which seemed to be contemp with the positive pressures on the front side. The for connecting the total pressure with the speed of the wind cou varied by a different coefficient, according to whether it w question of instantaneous pressure under a stroke of wind, i esting in regard to the stability of buildings, or of perma pressure under the influence of the return of air. An intere question, now that certain electric railway companies intend double their speeds, thus largely increasing the resistan the air, would be the reduction of this resistance. For front and rear faces the best means undoubtedly consiste providing them with convex pyramidal ends, so as to the air and to allow it to flow together again with the

possible disturbance. But what was the effect of the intervals which separated the carriages? According to the remarkable fact discovered by the Author with regard to the diminution of the total pressure on two plates spaced $1\frac{1}{2}$ times their diameter (*Fig. 10*), it appeared that there would be no advantage in blocking up these openings unless they reached a certain size. The matter remained doubtful, however, as for cylinders or prisms, the intervals, even if small, appeared to become serious. Thus in Table VIII., for example, there were two cylinders 1·64 inch long and spaced at 0·25 inch, that was to say, occupying altogether 3·53 inches, giving the same pressure (0·0025 lb.) as a single cylinder, with a length of 4·92 inches; and the pressure on this single cylinder increased with its length, the minimum being at a length of about $1\frac{1}{2}$ times the diameter, which was here 1·09 inch. In the same Table, the pressure of 0·00264 lb. for four cylinders spaced at 0·25 inch was very low; was there not an error here? Besides, the cylinders or prisms must offer a certain frictional resistance, and it seemed that it would be advisable to make further special tests in this direction. As far as bridges were concerned, it should first be noted that a plate girder did not fully cover another girder placed to leeward of it; for the girders acted like a pair of plates on account of their distance apart. For two lattice girders, allowing the air to pass through their spaces, the usual formulas always committed the error of not taking into account the movements of the surrounding air as a consequence of the interval between the girders. Table VII. showed that the pressure on one pair of lattice girders was less than on one alone with small intervals—a result which would not have been expected; then it went on increasing beyond a certain distance without ever attaining double the pressure on a single girder; that was to say, there always existed something of the effect of protection. Table XI., which applied to models of lattice girders, indicated for normal cases an increase of pressure for two girders compared with one alone, for small distances apart, but showed a diminution with a roadway. From this it might be concluded that the diminution would be still greater if there existed two floors, one below and the other above, which would prevent all action of the exterior air. It would be necessary for numerous tests to be made before the existing practical rules could be modified with safety. The question was of importance in connection with metallic viaducts of large spans and on elevated piers, as much for the calculation of the girders as for the stability of the piers in a direction transverse to the work. The influence of the sides of the

Prof. Gaudard.

Prof. Gaudard. Author's air-channel on too large a plate would be to exaggerate the pressure, reducing by friction the speed of the contiguous air and causing higher central speeds. Table IV. and *Fig. 9* showed that for a uniform current the pressure per unit of surface of rectangular plates increased in proportion as the relation of the length to the width increased. This was no doubt due to the fact that with narrow plates the air which had struck the windward side, escaped past the long sides with little deviation; it grazed the sides nearly normally, carrying away the air which existed at the back of the plate, and tending to produce rarefaction; further, the narrowness of the space behind left little room for the whirling afflux of the surrounding air to fill up the void: all causes which tended to increase the negative pressure on the leeward side. On the windward side, the reflection of the current exerted only a feeble resistance. Turning now to the oblique action on a rectangular plate (*Fig. 15*), which varied according as the short or the long side was inclined towards the current, the difficult point was to explain why the pressure in the second case was at first much greater and afterwards much smaller than that in the first case, as the obliquity increased. On the windward side, the air which had struck the most advanced portions tended to flow away principally by gliding downwards, and that in accumulating successively with the layers due to the following portions, it repelled the wind the more the plate was lengthened and decreased the pressure on the lower portions. This was an increasing resistance opposed to the flowing current. On the leeward side, the rarefaction of the air was produced especially towards the anterior edge of the plate, and initiated a call on the surrounding air, which later on tended to re-establish equilibrium or even to surpass it. Thus the pressure was at its maximum towards the anterior edge, especially at the back of the plate. If the line representing the pressure was curved instead of being straight, as *Figs. 16* showed, it pointed to the undulating character of the movement of the fluid.

Mr. Irminger. Mr. J. O. V. IRMINGER was gratified to find that the results of his experiments[1] in 1894 did not differ greatly from those of the more accurate experiments described in the Paper, which seemed to have been carried out in almost the same manner. In particular, the results for a roof sloped at an angle of 45° were practically identical. In a Paper read before the Institution of

[1] Minutes of Proceedings Inst. C.E., vol. cxviii. p. 468, and *Engineering*, vol. lx. p. 787.

Gas Engineers in 1899, he had described the effect of wind on such a roof as pressure on the windward side, diminishing in an upward direction, and suction on the lee side; and had stated that, adding together these effects, a resultant pressure was found, in an inclined upward direction, and equal to the wind's normal pressure multiplied by 0·38, which agreed with the result indicated in the Paper under discussion. As also mentioned in his paper of 1899, Mr. Irminger had made observations on roofs during a storm, by boring small holes in the slates, which holes were placed in connection with a pressure-gauge; and he had found that the pressure and suction conditions established by the experiments were clearly present, and varied with the strength of the wind. What he had demonstrated was that the old manner of calculating the wind-pressure on roofs was incorrect; and this view was borne out by the Author's remark that the experiments appeared to indicate beyond question the importance of a consideration of the negative pressure on the leeward side of roofs. His views had received further corroboration in a Paper[1] by Mr. J. Baier, who studied the effect of a tornado in St. Louis which demolished a large part of that city in 1896. Recently Mr. T. Nielsen had made calculations[2] of the effect of wind on roofs, on the basis of Mr. Irminger's experiments, and deserved credit for his attempt to do away with the incorrect methods of calculation hitherto used, which gave results contrary to experience. Mr. Irminger.

Mr. W. A. Price pointed out that in 1883 the late Sir William Siemens observed the resultant pressure at various points of a flat surface presented to the wind, in the following way. A wooden screen, about 15 feet square, was mounted on an iron telegraph pole, and stayed with guy ropes in such a way that it could be turned to face the wind. This was erected in an exposed place in the grounds of Sir William's house near Tunbridge Wells. In a horizontal row across the middle of the screen were mounted a number of pressure-gauges, which indicated the difference between the pressures on the two sides, and thus the resultant pressures on the screen at a series of points. Each pressure-gauge consisted of a glass U-tube with enlarged mouths. The liquid in the lower part of the tube was coloured, that in the upper parts clear, and the two did not mix. A small alteration of the levels of the free surfaces, due to a difference of pressure between the two sides of the screen, Mr. Price.

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[1] Transactions American Society of Civil Engineers, vol. xxxvii. p. 221.

[2] *Engineering*, vol. lxxvi. p. 508.

Mr. Price. produced a large movement of the surfaces separating the two liquids, and gave an easily observed indication of the resultant air-pressure on the screen at that point. According to his recollection Sir William Siemens had found the resultant pressure, when wind was blowing, to be greater near the edges of the screen than in the

Fig. 22.

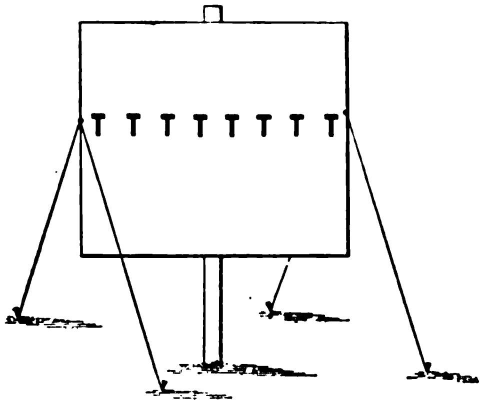
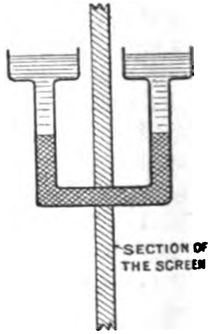


Fig. 23.



middle, and had suggested that in order to obtain the maximum total pressure on a given area, the length of the edge should be developed as much as possible. For a given sail-area the sails of a yacht might be full of holes. *Figs.* 22 and 23 showed the general character of the apparatus.

Mr. Scholefield. Mr. R. S. Scholefield considered that the Author's experiments were extremely interesting to engineers who had to design bridges and roofs. The effect of the eddy of the current of air on the test-surfaces did not appear to have been referred to in the Paper; the resultant of the wind pressure normal to the surface was alone given, and as this varied in different parts of the plate, was not the variation due to the effect of the motion of air in a direction parallel to the plate? Would not this motion parallel to the surface decrease the resultant normal to the plate, and produce a minimum normal effect at the point where the parallel motion was a maximum? In other words, the particles of air that impinged on the test-surface must move off somewhere, and the motion of these might be somewhat the same as if water were tried instead of wind. If water had been used for the experiments, the wash of the water along the plate and towards the only possible escape, namely, the edge, would have had to be taken into account; and it appeared that near the edge of the surface, where the velocity of

the water was at its maximum, the effect of the pressure of the water normal to the plate must be reduced. Would it not be interesting to note the leeward or negative pressure of wind on a plate girder? The same condition of pressure might be found when a train was passing over a lattice-girder bridge, or a tubular bridge such as the Britannia or Conway examples. The question of secondary pressures due to wind might also be extended to the case of sheds with open or discontinuous walls, such as many railway-station roofs, where the wind might enter at the side or end and produce a lifting effect on the roof internally, perhaps sufficient in some cases to lift it off the walls. Mr. Scholefield.

Mr. E. C. Thrupp observed that the very delicate tilting gauge for measuring the differences of pressure by Pitot tubes seemed to be a great advance on previous methods. Another good point about the experiments was that the pressures had been observed on stationary articles placed in a moving current, and not on articles moved in still air. The difference was important, and, although not very evident at moderate velocities, it would probably become more so if experiments were made at much higher velocities by both methods. It was unfortunate that the highest velocity of current employed was only 30 feet per second, because no troubles were met with in practice until much higher velocities were reached. The peculiar humps on the curves shown in *Fig. 15* indicated the angles at which the current, ceasing to divide and flow on each side of the plate, glided off entirely on one side. The width of the plate was shown to have a large influence in determining the critical angle, and therefore the conclusions drawn from small-scale experiments required confirmation on a larger scale. These observations, and also those on the screening effect of one object placed in front of another, tended to show that the course open to the flow of air round an obstacle was as important as the actual area of surface exposed, and that the total resisting-force was not in simple proportion to the area. It was doubtful whether the reduction of the force to pressure per square foot as a static load was really the best way of considering the question, because the element which caused trouble was the rapid fluctuation of pressure due to the turbulent motion of the air. A stream-line movement would never cause trouble, but violent eddies did. Silt was stirred up and transported in running water solely by eddying motion. Dust was stirred up by eddies in air. A tornado caused destruction along a narrow strip of land where the turbulent motion of the air was most acute, notwithstanding the fact that the mean forward velocity in the region of destruction Mr. Thrupp.

Mr. Thrupp. differed little or nothing from that of the air a few yards aw and outside the eddies. Turbulent motion set up shaking vibration simultaneously with the action of a fluctuating pressu in one direction, but sometimes reversed. Effects were produc somewhat similar to those resulting from loud deep-pitched noi which broke glass windows. Thus, in a tornado, windows a walls of houses were sometimes blown outwards, and this cou not be due to excess of pressure on the outside. It was to hoped that the destructive element of turbulence would be m fully recognized in future in connection with wind-pressu experiments. The proposed open-air observations at the Natio Physical Laboratory were to be welcomed, particularly beca they would afford information as to the pressure at higher velocit and under conditions of turbulent movement of air in hurrican and if the skill brought to bear upon the study of the fluctuati of pressure in various directions was equal to that displayed the apparatus described in the Paper, valuable scientific informat would certainly be obtained.

Mr. Wingfield. Mr. C. HUMPHREY WINGFIELD observed that the great delicacy the measuring-apparatus employed compensated to a large ext for the increased percentage of error involved both in the ma facture and use of such minute planes as the Author describ He would like to know whether the "wind-guard" referred to p. 80 was of horseshoe shape or whether it entirely enveloped lever. In the former case serious errors might creep in. In latter case how were eddy currents prevented in the open end? ' higher degree of uniformity in the velocity of the air through a given section of the tube, obtained by use of the Auth screens, was remarkable, as would be seen on referring to Me Heenan and Gilbert's Paper on Centrifugal Fans,[1] where velocities at different points in the diameter of an open air-c were shown to vary by 36 per cent. The perforated nozzle 2 *Fig. 3* was possibly better for the Author's immediate pur than the wire-gauze sandwich to which Mr. Wingfield had dire attention,[2] but it seemed probable that any considerable diverg of the current from parallelism with the axis of the nozzle w cause the readings to be erroneous. If so, it was not so good general purposes as the sandwich. Perhaps the Author would whether he had found the gauge-readings to be unaffected by direction of the wind. He was not sure that he understood the ol

[1] Minutes of Proceedings Inst. C.E., vol. cxxiii. p. 279.
[2] *Ibid*, vol. cxlvii. p. 235.

Mr. Wingfield.

of the central vessel in *Fig. 4.* Would not the instrument be equally delicate, as well as simpler, if BB were connected by a plain U-tube filled with water to a little below the bulbs? A little oil in each bulb would then give the necessary surfaces of separation for observation with the microscope, the tilting arrangement remaining unaltered. He did not quite see why the pitch of the vanes of the Author's air-meter was made varying; should they not be screws of uniform pitch, such that if the vanes were continued further towards the axis, their angle at the point where they were intersected by the roller-paths was 45°? In an ordinary report the 3 per cent. excess pressure, referred to at the top of p. 88, would be dismissed as an obvious mistake; but in view of the great attention to detail manifested in the Paper this was not likely. What, then, in the Author's opinion, was the cause of the discrepancy between fact and theory? Was it due to the action of the air-current on the lever and stem of the plane? The air would doubtless "pile up" above a disk to some extent owing to the restriction of the passage. This effect, though small, would be easily felt on the delicate apparatus used. Presumably, this was what was meant by "wall effect." Should not the current be measured at the side of the disks, in order to be comparable with the pressure experienced? Professor Hele-Shaw's experiments [1] had thrown some light on the possible cause of the extra resistance referred to. The tendency to approach each other shown by the shielded plates half a diameter apart was most interesting. Was this effect obtained with currents of high velocity? Some years ago a somewhat similar tendency of plates to approach each other when vibrating in air [2] and also in water [3] had been described in *Engineering*. He did not know if the phenomena were connected. Would the Author explain how the positions of the centres of pressure were determined experimentally by the method illustrated in *Figs. 14.* Were the models shown in *Figs. 17* solid block models or shells open at the bottom? In the former case, had their bases any effect on the result? To compare with actual buildings, the bases should be screened from the wind, and flanges, to represent the ground should be carried round the bottoms of the models so as to reproduce the effect of eddy currents. It was inconceivable that wind could blow straight down on and past a roof, owing to the effect of the ground. The roof of the model, he thought, should be made to move

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[1] Transactions Inst. Naval Architects, vol. xlii. p. 186.

[2] *Engineering*, vol. xxxiii. pp. 455, 480, 506, 558.

[3] *Ibid*, vol. xxxiii. pp. 28, 147, 191.

Mr. Wingfield. independently of the walls, base and ground; these should be fixe so as to avoid confusing the issue when it was merely required t ascertain roof pressures.

The Author. The AUTHOR, in reply to the Correspondence, remarked tha the paradoxical conformation of the lines of equal pressure o the windward side of the square plate, pointed out by Mr. Froude though it was a comparatively small effect, would be seen fron the observations recorded in Table I. to extend to the edge of th plate; for in that region, where the curve of equal pressure migh be expected to be a square, the pressure on the diagonal had negative value. With regard to Mr. Froude's scepticism as to th results obtained from the rectangular plates (Table IV.), he coul only say that the experiments had been repeated several times, an the values of the resultant pressure had been checked in each cas Mr. Froude appeared to be of opinion that the pressure on a rect angular plate depended entirely on the character of the flow, bu in the Author's view, although this would undoubtedly be the cas for the pressure on the windward side, it would not be the cas for the pressure on the leeward side, which, as he had mentione in the Paper, was an important factor in the pressure coefficien The experiments described by Mr. Mallock in the discussion als led to the same conclusion. As would be seen from the result given in Table IV., he had been unable to make experiments o similar plates having a ratio of length to width greater than 1 owing to the dimensions of the apparatus, so that possibly the hig values of the pressure coefficients obtained from the plates havin ratios of length to width ranging between 15 and 60 were partl due to the edge effect to which Mr. Mallock had called attentio With regard to the form of the vanes of the air-meter which ha been criticised by Mr. Wingfield and Mr. Gale, the vanes we designed so that the frictional resistance of the air moving ov them should be normal to the roller path, and should cons quently have no effect on their vertical movement. This co dition obviously would not be satisfied by vanes with a unifor pitch, for if the vanes were of the form suggested by Mr. Gal the friction would have a component along the roller-path, whic would render the instrument useless. In reply to Mr. Wingfield questions, the windguard entirely enveloped the lever, except the extreme end. In order to determine the effect of the eddies the open end, the lever had been balanced without any pressur plate attached to it, and then the air-current had been turned o It had been found that the eddy effect was quite negligible. Th effect of a slight tilt in the static-pressure tube was considerabl

and care had been taken that this was always parallel to the direction of the flow. The high value of the constant in the Pitot-tube formula was due, in the Author's opinion, to the form of the static-pressure tube, but he did not think the value was unduly high. The actual pressure due to the velocity of the current could not exceed the theoretical pressure, and would probably be somewhat below it in value; so that the value of the constant was on the right side of unity. The tendency of parallel plates to approach each other followed the general law that the attraction varied as the square of the speed up to the highest velocities obtained in the experiments. In the experimental determination of the centre of pressure by the method illustrated in *Figs. 14*, for any definite position which the plate took up, it was evident that the centre of pressure lay in the axis of rotation, since this contained the centre of mass of the plate and spindle. The models shown in *Figs. 17* were solid block models, their bases being prolonged in the direction of the current to represent the ground. The Author.

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12 January, 1904.

Sir GUILFORD L. MOLESWORTH, K.C.I.E., Vice-President, in the Chair.

The Council reported that they had recently transferred to the class of

Members.

Frederick Adams.
Ali Akbar.
Léon Harry Barker.
Robert Smith Black.
Frederick Bluett.
James William Bradley.
George Elliot Browning.
Robert Hearn Charters.
William Samuel Child.
George Jackson Churchward.
David Coe.
Albert Player Isaac Cotterell.
John Ernest Croasdaile, M.A., B.A.I. (*Dublin*)
Andrew Dougall, Junr.
George Lambert Gibson.
William Gilbert.
Robert Gould.
William Thomas Hatch.
Ray Douglas Theodore Heap.
Herbert Ross Hooper, M.A. (*Oxon.*)
Sydney Hutton Cooper Hutchinson.
William Hemming Jones.
Gilbert Laing-Meason.
Charles William Maclean.
Peter Valentine McMahon.
John Gibson Newbigging.
Walter Norman.
Richard Popkiss.
Seymour William Price-Williams.
Richard Septimus Rounthwaite.
Stephen Prescott White D'Alte Sellon.
John Francis Cleverton Snell.
Charles Edward Vernon.
George Whale.
John Robert Robinson Wilson.
Henry Woodall.

And had admitted as

Students.

Reginald George Cyril Batson.
George Arthur Beggs.
Oliver Carl Daniell.
George Alexander Easson.
Wilfrid Arthur Erlebach.
Wilfred Henry Montgomery Finch.
Albert Thomas Gosford.
Hugh Leigh Groves, B.A. (*Cantab.*)
Wilfrid Joseph Haskins.
Francis Albert Heymann.
John Cormack Johnston.
Jacob Benjamin Joseph.
Joseph Stuart King.
Walter McBretney, B.Sc. (*Lond.*)
Arthur Gordon McCrae, B.E. (*Sydney*)
William Ernest Wyatt Millington.
James Neilson.
Harry Lechler Nicholson.
Alfred William Okell.

Students—continued.

Alec Ferguson Osborne.
George Arthur Ostler.
Vincent O'Sullivan.
Geoffrey Arthur Peppercorn.
Reginald Peters.
Harold William Pink.
Pierce Francis Purcell, B.A., B.A.I. (*Dublin*)
Andrew Quartano.
William Charles Nelson Shilstone.
Alec James Simpson.
William Leonard Stampe.
William Fitzroy Scudamore Stallard Symes.
Thomas Bailey Tate.
Thomas Edward Thain.
Harvey Thomas Thorp.
Harry Topham.
Arthur Trevor-Roberts, B.Sc. (*Victoria*)
Edward George Walker.
Gilbert Walker, B.A. (*Oxon.*)
Thomas Waller Wallace.
Edward Stephen Warmington, B.A. (*Cantab.*)
Henry Owen Weller, B.Sc. (*Glasgow*)
Harry Hilliard Wilder.
Herbert Clarke Wilson.

The Scrutineers reported that the following Candidates had been duly elected as

An Honorary Member.

The Right Hon. Viscount Goschen, P.C., D.C.L. (*Oxon.*), LL.D. (*Cantab.*)

Members.

Conrad Keith Aird.
William Henry Anderson.
William Patrick Anderson.
Hans Charles Behr.
Lyonel Edwin Clark.
Henry Aylwin Bevan Cole.
Guilford Lindsay Edwards.
George Gibbs.
George Hughes.
Alfred Ernest Le Rossignol.
Nicol Finlayson Mackenzie.
Ernest Oscar Mawson.
William Morris Mordey.
Charles Croasdaile Ormsby.
Arthur Wells Robinson.
Charles Salmon.
Thomas Sims.
John William Sowarsby.
Arthur Spyer.
Henry Seddon Wildeblood.

Associate Members.

Allan Arthur, Stud. Inst. C.E.
Harold Cholmley Mansfield Austen, Stud. Inst. C.E.
Eric Samuel Sancroft Baker, B.A. (*Cantab.*)
John Aylmer Balfour.
Arthur Langtry Bell, B.E., B.A. (*Royal*)
Frederick Alan Biden, Stud. Inst. C.E.
Wilfrid Hocart Bishop.
George Blair, B.Sc. (*Glasgow*)
William Herbert Blaker.
Basil Tanfield Beridge Boothby.
William Nelson Bower.
Joseph Henry Draper Brearley, B.E. (*Sydney*)
Francis James Broadbent.
Robert Bruce, Stud. Inst. C.E.
James Thomas Harold Richard Hugh Ledicotte Burrell.
Cecil Bertram Case, Stud. Inst. C.E.
Kenneth Murray Chadwick, Stud. Inst. C.E.
Alfred Eustace Chambers.
Allan Fraser Cleland.
George Stephen Coleman.
Walter Gough Cooper.

Associate Members—continued.

Hugh Stowell Cregeen.
William Mark Cross, B.A., B.E. (*Royal*), Stud. Inst. C.E.
William Herbert Dack.
Arthur Albert Day.
John Dobbie.
John Reginald Hare Duke.
Joseph Edward Fadelle.
George Douglas Farwell, Stud. Inst. C.E.
William Robert Field, F.C.H., Stud. Inst. C.E.
William James Firth.
Samuel Henry Fleming, B.E., B.A. (*Royal*)
Henry Gould.
Charles James Grant, B.C.E. (*Melbourne*)
James Henry Grieve, B.Sc. (*Glasgow*)
Charles Gulland.
Henry Arthur Hardcastle.
Wallace Alan Douglas Harding.
James Harper.
George Spencer Harty, B.A., B.A.I. (*Dublin*)
George Patrick Hayes, B.A., B.E. (*Royal*)
Edmund Woodhouse Hedgeland, B.E. (*Sydney*)
Aidan Nicholas Henderson.
John Gordon Henderson, B.Sc. (*Glasgow*)
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(*Paper No. 3428.*)

"The Electrical Reconstruction of the South London Tramways on the Conduit System."

By Alexander Millar, Assoc. M. Inst. C.E.

The extreme caution exhibited in this country during the past decade in dealing with new developments of traction problems has been in striking contrast with the enterprise displayed in other countries, and with the position held by England in the early days of mechanical traction. This is rendered particularly noticeable by the scarcity of convenient and cheap means of surface transit for residents in towns and in other thickly-populated districts. Probably there could be no better illustration of lack of enterprise than was afforded by the backward condition of tramways in London 4 years ago. In 1899 no electric tramways were in operation in any part of London, and the work of constructing the first short length of electric tramway had only been commenced. In this respect London was considerably behind even most of the other large English towns, as they, encouraged by the popularity and financial success of tramways in America and on the Continent, had overcome their timidity, and had either electric tramways in operation or extensive works in hand for replacing the antiquated horse-traction and the almost equally unsuitable and more unsightly steam-traction. Previous to 1900—when the first electric line was opened in London, namely, that of the London United Tramways Company between Hammersmith and Kew—the only successful mechanically-worked line in London worthy of mention[1] was the Brixton cable-line, constructed in 1892, and consisting of about 7 miles of single track. A short history of London tramway undertakings will show how this unsatisfactory state of affairs came about.

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[1] The total route length of the Highgate Hill cable-tramway, laid in 1884 is under ¾ mile.

History of London Tramways.

Endeavours were made as far back as 1861 to establish tramways in London, but owing to the crude form of construction adopted, they were abandoned, and not until 1869 were tramways successfully established. In 1870 a great stimulus was given to tramway enterprise by the passing of the general Tramways Act, and within a few years a large and somewhat complicated network of horse-tramways, owned by various companies, was in existence in London.

In 1891 the London County Council, created in 1889, availed themselves of the powers granted by Section 43 of the Tramways Act, 1870, and on the break in the concession of the two companies in North London (the North Metropolitan and the London Street Tramways Companies) gave notice of their intention to purchase. Prolonged litigation as to the purchase price followed, and it was not until 1895 that the final settlement was effected. The Council at that time had no powers to work tramways, and re-leased the lines to the companies for a short period. Eventually, in 1896, a lease, to work for a period of 14 years the whole of the lines purchased, was arranged with the North Metropolitan Tramways Company. Certain clauses in the lease empower the Council to reconstruct the lines for electrical traction. Charges of interest on the capital expenditure involved would be borne by the company.

At the end of 1898 the Council became owners of the London Tramway Company's lines in South London, covering 24 miles 3 furlongs of streets. Subsequently 2 miles 5 furlongs and 13¼ miles (South East Metropolitan and South London Tramways) were acquired in April, 1902, and November, 1902, respectively, making in all 40¼ street-miles of tramways, representing 73 miles of single track.

The Council's tramways now comprise 93½ miles of single track in North London, leased to the North Metropolitan Tramways Company, and 73 miles of single track owned and worked[1] by the Council in South London. The leases of the four smaller remaining Metropolitan tramways expire at different periods during the next 4 years.

As far back as 1896 the Council's attention was drawn to the need of electrical traction for their tramways, but it was not until

[1] The London Tramway Act of 1896 gave authority to the Council to work tramways.

1898, when they began to work the horse-tramways themselves, that the scheme took definite shape. In that year Mr. J. Allen Baker, then one of the members and subsequently Vice-Chairman of the Highways Committee, presented a report on the different tramway systems he had inspected abroad and at home, giving particulars as to their mechanical and financial working. In March, 1899, the Committee called in Dr. Alex. B. W. Kennedy to advise them "(*a*) as to the best system or systems of mechanical traction other than steam or cable, for adoption on the tramways; (*b*) where, or under what conditions, an experimental line could best be introduced to initiate such system or systems; and (*c*) generally on the whole matter."

Dr. Kennedy submitted to the Highways Committee a report on the whole matter, in which, after reviewing the various systems in use, he recommended:—

(1) That in the great central zone of London, with streets where a very considerable car-service might be anticipated, having numerous junctions and crossings of the most complicated character, the Council should adopt the open-slot conduit, equipped for electric traction, as the system best suited for their requirements: this zone to extend over the greater part of North London, and over a large strip south of the Thames.

(2) That in the suburban and semi-rural districts, where tramways have for the most part broad, straight streets and few junctions with other lines, the overhead system of traction should be adopted.

(3) That the whole should form a combined system so designed that the same cars, suitably equipped, should, where desirable, be able to run over both systems.

With lines and cars properly equipped, the operation of changing from one condition of running to the other did not, in Dr. Kennedy's opinion, need to occupy more than a few seconds. At the time of writing the report the proposed system had actually been installed in several American towns, in Berlin, and in Brussels. The method used in America for changing over was somewhat primitive; but in the two last-mentioned towns the problem had been carefully considered, and the operation was performed quickly and accurately.[1]

The Council adopted this report, and resolved to take steps at once to acquire powers from Parliament to convert their existing tramways. They also decided that the first lines to be equipped

[1] Proceedings Institution Mechanical Engineers, 1901, p. 384.

with the conduit should be the lines south of the Thames from Westminster Bridge to Tooting, and from Blackfriars Bridge to Kennington; afterwards they added to these the line from Waterloo Bridge to St. George's Circus. This means, in other words, the tramway lines running from the three Thames bridges at Westminster, Waterloo, and Blackfriars, to a southern terminus at Tooting, having a route length of over 8 miles and consisting of about 16¾ miles of single track (Fig. 1, Plate 2).

During the passing of the Bills through Parliament, most of the borough authorities, which are the road authorities, expressed themselves emphatically against overhead traction in any form; thus providing the Council with another strong reason, had it been required, for proceeding with the more expensive system of conduit construction. The Bills were finally passed in August, 1900, and provision was inserted that, before actual construction began, plans must be submitted to the road authorities of the various boroughs concerned, for approval, and to the Board of Trade. A clause was also inserted that nowhere should overhead construction be employed without the consent of the road authorities of the district. The consent of the Board of Trade and of the borough authorities of Lambeth, Southwark and Wandsworth, within which the Tooting lines lie, was finally obtained in the spring of 1901 and, as by that time the other formalities prescribed by the Act had also been attended to, the working-drawings and specifications for the final scheme were proceeded with, and the various contracts were let.

In this Paper on the South London tramways, such features of the work as station-plant and equipment, car-depots, rolling stock (apparatus for collecting current excepted), etc., which are more or less the same for overhead and conduit systems of electric traction, will not be touched upon otherwise than by a passing reference; but the Author proposes to submit details of three branches of the work, namely:—

(1) Construction of Permanent Way,

(2) Electrical Distribution on the Line,

and (3) Collection of Current;

which present considerable contrasts with the overhead system and therefore are typical of conduit construction. It will not be convenient altogether to separate the first two heads, but this course will be followed as much as possible.

The width of the slot played an important part in decidin

the design of the conduit. The choice of form lay between a conduit under one of the wheel- or track-rails, and a conduit between the track-rails. The advantages of the former method are simpler and cheaper construction, and less ironwork in the street-surface; but it has one very serious drawback. The width of the rail-groove, and consequently of the slot, would require to be, on straight and easy curved portions of the line 1 inch, and on sharp curved portions 1¼ inch.[1] Even under the best conditions of construction, with a 1-inch slot maintained throughout, the side conduit could not have been adopted for London. It was only with the greatest difficulty that the local authorities were induced to agree to a slot ¾ inch in width, as they pointed out that cable-tramways had been laid with a ⅝-inch slot. Accordingly, the central slot was adopted for London. With this arrangement, it is possible to maintain a uniform slot of ¾ inch throughout, the conduit is kept cleaner, there is less vibration of the conductor-bars, and access for inspection can more easily be obtained.

Another point which received careful consideration was the depth of sub-surface obstructions. In England a very large number of gas-, water-, and other mains are laid in roads at a depth of 2 feet 6 inches to 3 feet below the road-surface; and, as London was no exception in this respect, it was decided that the culvert adopted should be kept as shallow as efficient working would permit.

Road-Work and Permanent-Way Construction.

The general arrangement of road-work construction is shown in Figs. 2–6, Plate 2. A conduit or tube, which runs the entire length of the lines, is formed in each track, exactly central between the running rails. The bottom and sides of the conduit proper are composed entirely of 5-to-1 concrete and cast iron, and the top consists partly of the same materials and partly of two ⅂-shaped rolled "slot-rails" (Fig. 7). These slot-rails form together the opening, or slot, by means of which communication can be established between the car-motors and the conductor-bars.

From Figs. 2–4, Plate 2, it will be seen that at intervals of

[1] These widths are necessary to ensure easy running for the car-wheels, and do not depend on plough-clearance. Had the latter been the only consideration, the sizes might have been less.

3 feet 9 inches are placed cast-iron supports or yokes, weighing 160 lbs., and having underneath and at their backs pockets of concrete which act as a foundation and buttress to the yokes. The inside of the conduit is brought to a smooth surface with cement plastering, and in the finished state the panels correspond exactly with the inside face of the yoke, the latter in building forming a gauge for the centering of the concrete.

The yokes which carry the slot-rails resemble the letter U in appearance (Figs. 8). They have a normal breadth of 6 inches at the sides and bottom, but vary in section. On comparing section A A with section B B it will be seen that the yoke has considerably more metal at the sill than at the sides. The object of this is to make the yoke equally capable at all parts of withstanding horizontal forces tending to bring the slot-rails together. The greatest stress on the yoke from these forces is at the sill, which has been increased in section to meet it. It has been found, from tests with short pieces of slot-rail attached to yokes as in actual construction, that it requires a horizontal force of 10½ tons, applied half-way down the web of the slot-rail, to break the castings. To achieve the same result when the yoke is concreted in place, however, this force would require to be enormously increased, in order to overcome the anchoring effect of the concrete.

The weakest part of the concrete construction is at the edge of the slot-rail flange (Fig. 2). At this point the depth of concrete, measured on the slant, is only about 2½ inches; hardly sufficient, unless the concrete has thoroughly set, to withstand the jarring incident to the removal of the wooden centering, which usually takes place about 36 hours after the concrete is laid. In order to protect this green concrete from injury when the shutters are being removed, iron paving-plates, 3 feet 6 inches by 2½ inches by ⅜ inch, are inserted in each bay, immediately under the edge of the slot-rail flange. Figs. 8 show the recesses in the yokes into which the ends of the paving-plates are slipped.

The upper part of the yoke has two substantial seats, or jaws, to which the bottom flange of the slot-rail is bolted by two ¾-inch bolts passing through each seat and having square heads underneath the seat (Figs. 8). Owing to the close proximity of the stiffener, shown underneath the yoke-seat in section A A, the bolts cannot turn when being screwed up. Where the slot-rail bears on the yoke-seats, raised fitting-strips are provided, so as to ensure a proper bearing.

At the other end of the yoke-head are two projections or lugs, with a 1⅛-inch passage between them, to which the steel tie-bars

keeping the slot- and track-rails in their true position, can be secured. The tie-bar fixing the slot-rail to the yokes is seen in place in Figs. 8, and its various details are shown in Figs. 9, Plate 2. The bars have screwed ends, and in order to suit the paving, the middle is made rectangular. One end, furnished with a nut and washer, passes through a hole in the web of the slot-rails, the washer butting against the inside face; the other end is fixed in the passage between the two lugs in the yoke-head, by a nut. When fixed in position, the tie-bars provide a ready means of adjusting the slot-rails horizontally. The shoulder formed 2 inches from the slot-rail end of the bar (Figs. 9) prevents the bar from entering too far inside the slot-rail and forming an obstruction to the passage of the plough. The object of the bend in the bar is to allow the tie-bar to pass at right angles through the web of the slot-rail, thus securing a straight pull and avoiding the use of tapered washers. Under test it was found that the force required to straighten the bars is 12 tons, and the tensile force required to break them is 18 tons.

No fishplates are used at the slot-rail joints: the ends of the slot-rails are supported by a yoke placed immediately underneath, and the rails are kept to line by the use of the ordinary tie-bars with the help of the extra large washer (Figs. 9), which gives a good bearing inside the web of the rail. At a joint, the tie-bar passes through a half-hole in each slot-rail end. This arrangement of joints has been found to work well in practice. The only objection the Author has found to its use on the South London lines has occurred at very sharp curves, where some little trouble has been experienced in getting the rail-ends to true line and level. It would have considerably assisted the work of getting the slot-rail ends to line here had a substantial flat plate been used for bolting the webs together.

There is a large gathering of metal at the slot-rail head (Fig. 7), the object of which is to stiffen the head against side pressure, and to provide a drip along the inner edge of the slot. It is important that muddy surface-water finding its way into the slot should be intercepted here, and thus be prevented from creeping farther down the slot-rails and dropping on to the conductor-bars.

The conductor-bars, shown in Figs. 2, 3 and 6, are two ⊥-shaped bars insulated from the conduit which convey the current along the line from the feeding-points, one forming the positive conductor and the other acting as the negative return. The shape and position of these bars determined, in a large measure, the size and general

design of the conduit. As regards shape, the ⊣ shape was chosen as being a very suitable section for facility of erection and for rigidity (which is an important point) as well as for affording a suitable rubbing-surface for the plough-contacts, which are shown in place in Figs. 33, Plate 3. The sectional area of each bar is 2·15 square inches, which is large enough to provide for the maximum number of cars on a section, and can, in an emergency such as arises from the breakdown of a feeder, convey current to another section. As regards position, it will be seen that the bars are so placed that débris falling through the slot cannot land on them; and further, it is a very difficult matter for any one pushing a rod down the slot to touch the bars.

The actual distance apart of the faces of the bars, namely, 6 inches, is determined by the space necessary for the plough. It should be sufficient to admit a plough designed so as to have proper mechanical strength and efficiently insulated leads, as well as the contact-shoes and side springs, by means of which the rubbing contact is secured.

The distance from the side of the conduit, and the depth from the top of the slot-rail, are kept as small as is consistent with good insulation and ease of construction. The air-space between the bars and the side of the conduit is 2 inches, and above the bars the space is about 3 inches. At the sides, with a substance like concrete, liable to slight irregularities, it would be unsafe to run clearances too fine, and in practice it has been found that a 2-inch air-gap is necessary. At the top, the conditions in this respect are better, and, were clearance the only consideration, the bars might have been raised slightly; but this would have meant reducing the insulator or the depth of the cover, because the covers on the top of the inspection-pits are very close to the insulators, and do not permit of the latter being raised. Experience on other lines tends to show that it is undesirable to employ less insulation; and as regards the depth of cover, the stones have been kept as shallow as is consistent with sound paving. An alternative would have been to reduce the depth of the cover by using some other paving material, or to employ a plain iron cover on the surface of the roadway. In the former case a mixed and less satisfactory street-surface would have resulted; and in the latter case the local authorities would certainly not have agreed to the additional iron on the street-surface, and probably the Board of Trade also would have objected.

The space between the underside of the bars and the sill is [illegible] it has been found by experience elsewhere

that this is as small as is consistent with efficient and economical cleaning and working of conduit lines. It is quite permissible, however, to reduce the depth of conduit by 4 inches for a short distance, and it has been done in other lines[1] without any serious trouble. With shallow conduits the sewer-connections should be increased and the bars be raised if possible.

The conductor-bars (Fig. 10, Plate 2) are of very mild steel. A particular condition attached to their manufacture was that the quantities of manganese and carbon should be kept as low as sound rolling and strength would admit, so that high conductivity might be secured. It was also considered desirable that the bars should be sufficiently ductile to be easily bent for line curves. The contractors, under the contract, guaranteed that the carbon would not exceed 0·12 per cent., and the manganese 0·45 per cent.; also, that the conductivity would not be less than 10 per cent. of the Matthiessen standard for pure copper. From careful tests of the first rollings, made with material having a composition within the guaranteed limits, it was found that a conductivity of 14 per cent., or $\frac{1}{7\cdot 14}$, was secured; and, as some difficulty had been experienced in rolling the bars from so soft a material, a slight increase was allowed in the amount of carbon and of manganese. Taking the area of the bars at 2·15 square inches, and the conductivity at 14 per cent., the equivalent area of copper is 0·3 square inch, and with conductivity 12 per cent. it is 0·26 square inch. The bars weigh 21½ lbs. per yard, and have a tensile strength of 25 tons per square inch. They are supplied in 30-foot lengths, and are supported at both ends and at the middle by insulated supports hung from the slot-rails. These supports (Fig. 11, Plate 2), consist of an outside iron shell or armouring, having a projecting lug, which is fixed by two ¾-inch bolts to the bottom flange of the slot-rail. Cemented inside this armouring with neat Portland cement is a porcelain cup of special quality, with corrugated sides corresponding with corrugations in the inside of the armouring, so as to give the cement a secure hold. A similar arrangement of cementing is followed with the insulator-rod, which is, in turn, let into the inside of the porcelain. These insulators, in common with other porcelain insulators, have had two firings in the process of manufacture; namely, the "bisque," in which the unglazed article has been thoroughly burnt and become vitreous, and the "gloss," which is undertaken, after dipping the burnt

[1] By the Compagnie Générale Parisienne de Tramways.

article in the glazing compound, in order to flux the glaze. The finished article is of a particularly vitreous character, and consequently practically impervious to water.

In filling in the cement between the bolt and the porcelain, care is taken that it is kept away from the bottom edge of the porcelain. This prevents any water which may percolate down the outside of the porcelain from getting on to the stalk of the insulator-rod. A shoulder is formed half-way down the insulator-rod (Fig. 11), and the lower end is screwed and provided with a special nut. Between this special nut and the shoulder a cast-iron clip (Figs. 12 and 13) and an adjusting washer (Figs. 14) are inserted. The clips are made to fit the tapered web of the conductor-bars, and the tapered cotter (Figs. 12) is inserted to keep the conductor-bars in place. Adjustment of the conductor-bar is made by means of the special washer (Figs. 14) placed on the top of the forked clip. The lower part of this washer is circular, the upper part nut-shaped, and the hole through which the rod passes is out of centre. When the nut-head is worked, an eccentric action takes place, the clip moving inwards and outwards. The total adjustment possible is 1 inch, that is, ½ inch either way. A longitudinal adjustment of ¾ inch is provided by oblong holes in the lug of the armouring, and any further longitudinal adjustment, which is rarely necessary, is made by cutting the conductor-bars or drilling fresh holes in the slot-rail flange. Normally no drilling is required, as all rails are drilled before leaving the maker's works.

The conductor-bars break joint, and at each joint two stranded copper-bonds, each 0·108 square inch in section, connect the adjacent conductor-bar ends together. They have solid terminals ¾ inch in diameter, and are shown in position in Figs. 19, Plate 2.

The electrical test specified for the insulated supports was as follows:—The complete insulated support, consisting of armouring, porcelain insulator and suspension-rod, was immersed in water for 24 hours, and then taken out and the porcelain carefully wiped with a cloth. Immediately afterwards the support was inverted, *i.e.*, placed with the screwed end of the rod uppermost, and immersed in water until the armouring was just covered; and in that condition it had to stand a 2,000-volt alternating pressure between the metal armouring and the rod, for a period of 15 minutes, without breakdown. Any insulated support which showed leakage under this pressure was rejected, and the porcelain insulator was broken. Frequent tests were made during the progress of the work, and in every case the results were satisfactory. Usually a batch of six or more

insulators were connected up together by means of a fine wire to the source of supply and tested. In addition to the foregoing test, each ½-mile section of completed track was tested for ½ hour with 2,000 volts alternating between the two conductor-bars, and with 1,000 volts alternating between each bar and earth. Tests were carried out in all kinds of weather, and in no case did a breakdown occur.

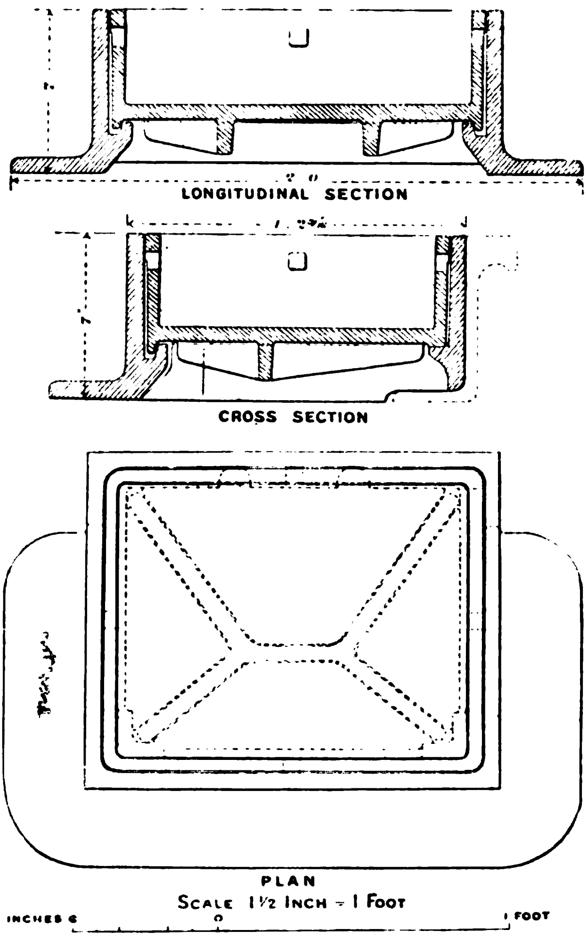
Means of access to these insulated supports, which are placed 5 yards apart, is provided by the inspection-chambers shown in Figs. 3–6. These chambers are formed by widening out the tube, on both sides of the centre-line, from 7 inches to 16 inches, for a length of 16 inches. The walls and floor of the pits are of concrete, and the floor has a rapid fall to the tube. The inside of all the inspection-chambers is plastered with 2-to-1 Portland-cement mortar, the whole surface being brought to a smooth finish. Cast-iron boxes, consisting of frame and cover (*Figs. 15*), are placed over the insulator-chambers, and these boxes are made deep enough to allow 3¾-inch stone sets to be laid in them.

The 7-to-1 concrete bed, which is carried right across the tramway construction, provides a substantial foundation for the track-rails and paving. On the top of this bed a layer of fine cement bedding (3 to 1), about 1 inch thick, is placed, on which the track-rails are laid, the bedding being packed carefully underneath the track-rails.

It will be seen from Figs. 2 and 5 that the track-rails are brought to gauge by means of steel tie-bars (Figs. 16, Plate 2) in the same vertical plane as the slot-rail tie-bars, one end passing through the slotted hole in the web of the track-rail, and the other end which is forked, being securely fixed to the lugs on the yoke-head. This is done by jamming the two prongs at the end of the tie-bar into the special recesses formed at the lugs (Figs. 8). The prongs are slightly wedge-shaped, and are secured in place by screwing the middle nut on the slot-rail tie-bar (Figs. 9) until it jams the prongs into the pocket at the cast-iron lugs. The adjustment of the track-rails to gauge is made by means of the nuts and washers on the tie-bar at both sides of the rail. There is a considerable advantage in employing separate tie-bars for the slot-rails and track-rails, and in having one end of each rigidly fixed. By such an arrangement a perfect means of control is secured for gauging either the slot-rail or the track-rail independently. In conduit construction tie-bars have frequently been used directly between the slot-rails and the track-rails; but, in the Author's opinion, such an arrangement is a mistake, because

the rails cannot be so carefully controlled as when an independent gauge-point is used, and when one member is considerably weaker than the other there is always the danger of movement of the weak

Fig. 15.



CAST-IRON COVER FOR INSULATOR-CHAMBER.

member. Further, the paving is not broken up so much by keeping the slot-rail and track-rail tie-bars in the same vertical plane, as it would be if a tie-bar were inserted from track-rail to slot-rail midway between the yokes.

Fig. 17 shows the ordinary track-rails laid at all parts of the line except the sharp curves, junctions and crossings. They weigh 102 lbs. per yard, and have a tensile strength of 42 to 49 tons per square inch. The joint, which is formed by cutting a sleeve $\frac{3}{4}$ inch wide out of the track-rail head for a short distance at the rail-ends, and replacing the metal cut away by a deep fishplate whose upper surface is flush with the rail-head, breaks the rail-joint, and provides a continuous running-surface for the car-wheels. This form of joint has been extensively used of late years in tramway undertakings in this country, and the Author's experience of it on the South London and other lines has been favourable. Care must be taken to secure the right height of fishplate, and to gauge correctly the extent of the cut in the rail-head. A 15° fishing-angle is used, and at the bottom the fishing-angle does not extend to the tip of the flange, as, had it done so, the amount of metal in the flange would have been needlessly increased. At sharp curves a slightly heavier rail (Fig. 18), weighing 104 lbs. per yard, with wider groove and broader lip, has been employed. It was considered safer to have longer fishplates here, owing to the greater liability of rail-joints to work loose on sharp curves and at crossings, etc. The holes in the rail-web for the tie-bars allow an adjustment of $1\frac{5}{8}$ inch in one direction.

The drainage-arrangements for the conduit (Figs. 19) are as follows. Approximately at intervals of 60 yards the ordinary insulator-pits in each track are deepened and connected with a sump in the tramway-margins by a passage having a gradient of 1 in 10. The frames of the catch-pits are the same as the ordinary insulator pit-frames, but a cover with special ribbing is used, so that the insulator can be placed to one side, leaving more room for cleaning. The sump in the margin acts as a settling-chamber for the solid matter discharged into it. The concrete walls and sill are rendered inside with cement mortar (3 to 1), and the sill is rounded to facilitate the cleaning-operations. At the outlet to the sewer, a cast-iron hood is fixed to the wall, and checks the flow of mud into the sewers and the escape of sewer-gases into the sumps, and thence into the tramway conduits. In most cases a 12-inch pipe, encased in concrete, connects the sump-pit with the sewer, but the diameter has been reduced to 9 inches and even 6 inches in special cases. Access to the sump is obtained through a cast-iron frame with cover, having an opening 18 inches square, and step-irons are fixed in the side walls to allow a man to get in and out. The distance apart of the sewer-connections has been determined by the grading of the road-surface. On flat parts,

they have been introduced as close together as 40 yards, but where the streets have good gradients, the distance has been increased to slightly over 80 yards.

Immediately in front of all junction-points, and at breaks in the conductor-bars at feeding-points, there are gaps in the slot-rails, in which frames and covers have been inserted, constituting what is called a "plough-box" (Fig. 29, Plate 3). The covers are chequered on the top to provide foothold for horses, and can be lifted out by inserting hooks at the two ends. When they are removed, a clear opening is obtained, 3 feet $6\frac{3}{8}$ inches long by $9\frac{1}{2}$ inches wide. At junctions the principal object of these boxes is to provide an opening for taking in and out the curved conductor-bars on the branching line; they can also be used in an emergency for removing a damaged plough from the track.

It will be seen from the route map (Fig. 1, Plate 2) that in addition to the ordinary road-work a very considerable amount of special work has been required in the form of junctions, crossings and cross-overs. There are in all seventeen single or double junctions, five double-line crossings, and ten crossover roads, and the cost of this special work is approximately one-eighth of the whole road-work contract. At one or two points on the route, such as St. George's Circus, Clapham Road at the car-sheds, and the "Elephant and Castle," the interlacing of lines is very extensive; and it is doubtful whether there is any other point in London where a more intricate network of lines is to be found than at the "Elephant and Castle."

All the crossovers and car-shed junctions are arranged with trailing points, and at other places the number of facing points has been restricted as far as possible.

In designing the special work, an endeavour was made to standardize similar parts wherever possible. One result of this is that only two sets of point-castings have been employed for the junctions and crossovers, one right-hand and one left-hand; and both are formed to the same radius. A further example of extensive uniformity is to be found in crossovers, which have all been made to the same design, and, in a less degree, in the crossing-work at junctions. Particular attention was paid in all parts of the special work to securing good bearing-surfaces by machining, and fish-plates were accurately fitted at all joints before leaving the maker's yard. The work at junctions, etc., in conduit construction is considerably more complicated than ordinary tramway-track construction, owing to the extra lines of metal. Many of the

castings have no other support than the yokes, spaced 3 feet 9 inches apart, and they have to be sufficiently substantial to carry all the street traffic across this span without working loose or requiring frequent renewal.

The work at a typical junction is illustrated in *Fig. 20*, and at a typical turn-out or crossover in *Fig. 21*. The rail-work is formed of steel castings and rolled rails, and the castings vary considerably in form and dimensions. The shortest, 12 feet in length, is the box casting for track-tongues, and the longest, 22 feet, is laid where the two slots cross in a junction (*Fig. 20*). The use of short rolled rail closures has been restricted at junctions to one 8 feet 7 inches in length, and at crossover roads to two 9 feet 10 inches in length. By this means the number of joints has been reduced to a minimum, and the whole structure has gained in strength and stability.

Fig. 22 is an example of a double-line crossing. The two tramways cross practically at right angles, and only eight castings are employed to furnish all the rail surface-work. With the exception of the two castings in the centre, the slots form the dividing line between the various castings, and each casting supplies all the rail metal within its boundaries. *Fig. 23* shows the type of yoke used to support the superstructure at each slot-rail crossing. Chiefly for reasons of transport[1] it is made up of four similar parts, each casting forming one side of a central square and a diagonal arm. The slot-rails are borne chiefly by the central square, and the radiating arms support the track-rails. At slot-rail crossings where the angle of crossing is acute, extra long supports are necessary, and these are built up of lattice girders. At track-rail crossings where the tread is broken, the floor of the groove for some little distance on each side is brought up within $\frac{1}{2}$ inch of the rail-head, so that the wheels may ride on their flange when passing this point, and thus secure continuous running. In addition, at these places, specially hardened steel cores have been let into the casting, in order to provide a more durable surface. The life of the whole casting is of course considerably increased by using these renewable pieces at parts where the effect of wheel-traffic is most felt; and it is asserted that in this way the castings may be made to last as long as the abutting rails. In order to meet the greater risk of slot-closure at special work, one or more expansion-joints of $\frac{1}{8}$ to $\frac{1}{4}$ inch have been allowed on all rails crossing the slot.

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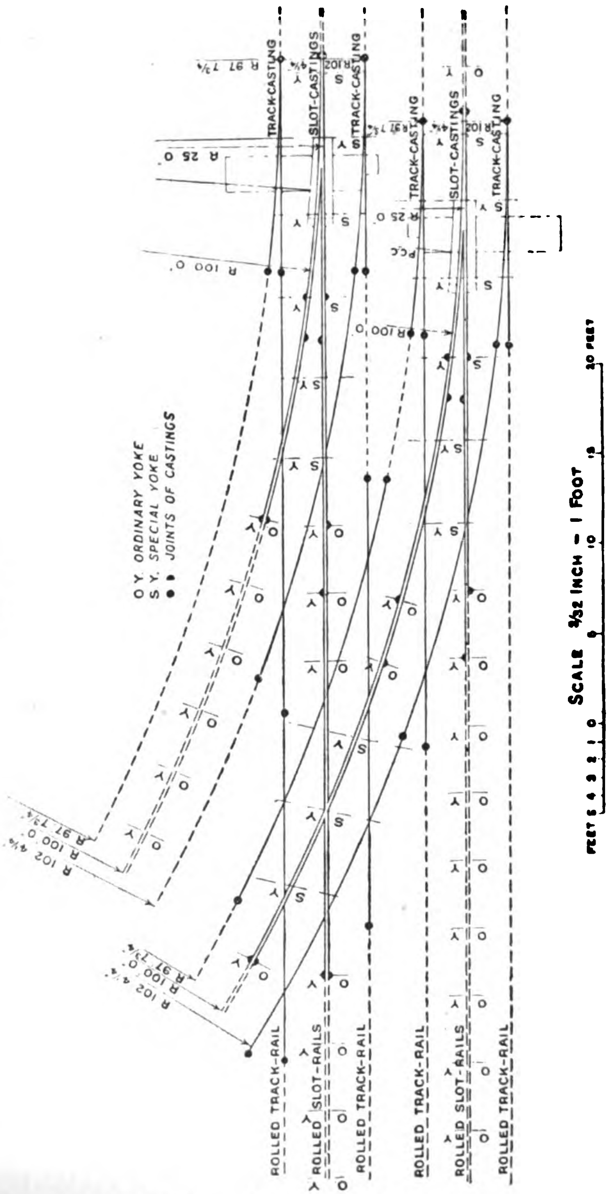
[1] The castings for the special work were made in America.

Details of the special yokes used in a crossover road are shown in

Fig. 20.

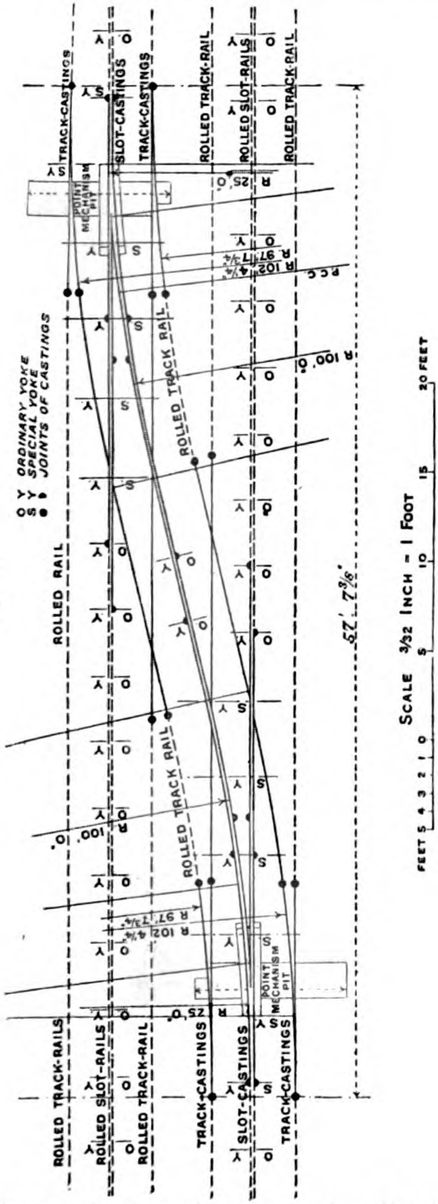


STANDARD JUNCTION.

Figs. 24–27, and those used for a junction are very similar in

character. In addition to supporting the slot-rails, the yokes

Fig. 21.



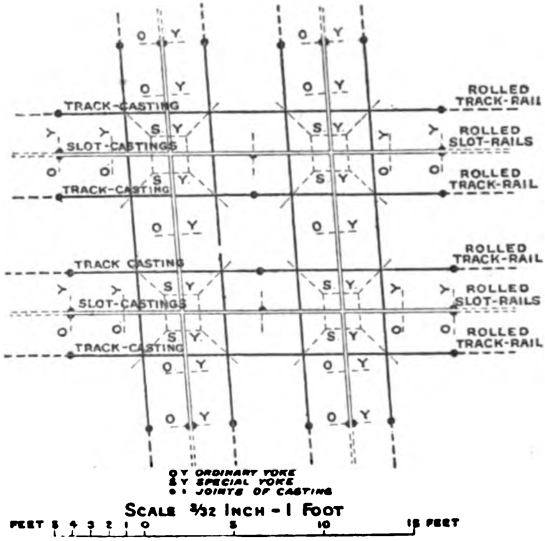
STANDARD CROSSOVER.

have extended arms for carrying the track-rails. This form of

yoke is of great assistance in erecting and connecting together the many different pieces at special work, where the large amount of ironwork prevents the use of ordinary tie-bars; and it enables the whole structure to be jacked up in place and concreted in one length.

Figs. 28 and 28*a*, Plate 3, show the pit in which is installed the linkwork for operating the slot- and track-rail tongues. In the event of the linkwork requiring adjustment, most of the parts can readily be reached from the street-surface when the covers are removed. Both track-rail points are equipped with an 8-foot

Fig. 22.



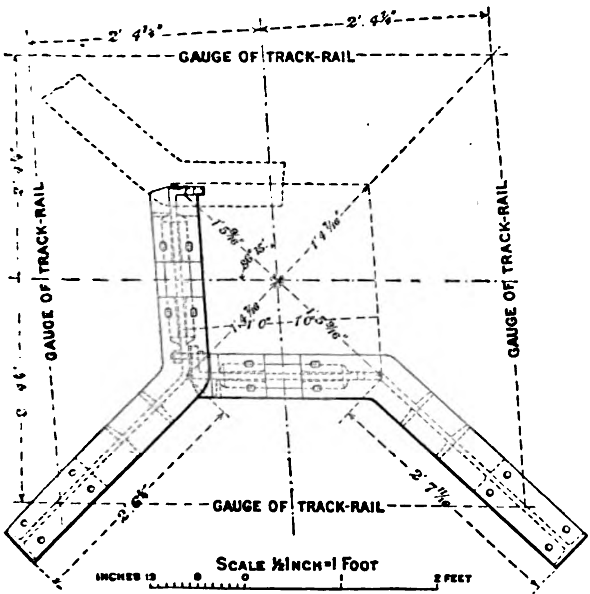
STANDARD CROSSING.

movable tongue: this practice has been adopted throughout for both facing and trailing points, and it is considered that by thus avoiding the use of dummy or open points, smoother running of the cars is ensured, and the cost of maintenance is reduced. It will be seen from the plan that the track- and slot-rails do not divide at the same place. The radius of the slot is 25 feet, as compared with 100 feet for the inside track-rail. The sharp curve is introduced into the slot construction in order to reduce, as much as possible, the length of the overhanging portion of the tapering slot-point, which is difficult to strengthen. The device has the effect of throwing the slot slightly out of the

centre of the track, but this does not in any way interfere with the passage of the plough, which, as will be explained later, is free to move horizontally to either side of the car. Had the slot been curved to the same radius as the track, the overhanging portion would have been 8 feet instead of 5 feet 9 inches. With the longer length the difficulties of securing a slot-point sufficiently rigid to withstand street traffic would have been increased, and a longer break in the contact with the conductor-bars would have resulted.

The plough with extended springs, which is the chief factor

Fig. 23.



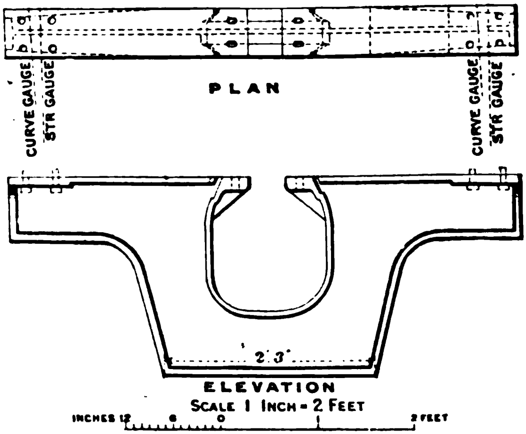
SPECIAL YOKE FOR CROSSING.

determining the length and design of the gusset-post, is outlined in *Figs.* 26.

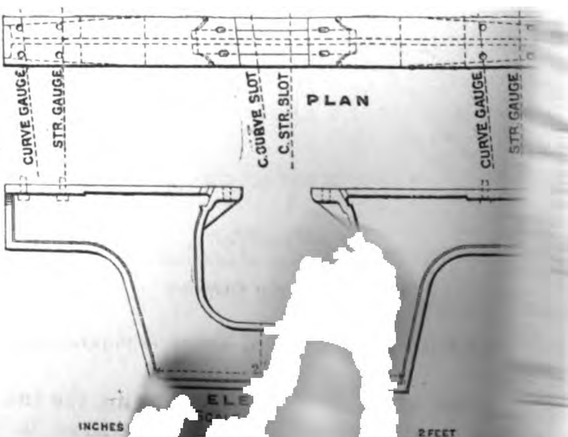
A brief description of the mechanism for moving the two track-tongues and the two slot-leaves, which may have to be all connected together and so arranged that they can be moved simultaneously by working a hand-lever alongside the track or on the footpath, is as follows:—The two slot-leaves B and B′ (Figs. 28*a*) are connected by links C and C′ to vertical levers D and D′ pivoted on shafts E and E′, and also connected together by an adjustable link G. The adjustable link H connects lever D to the

bottom of rocker J, which is pivoted on the shaft K. In o that the track-tongues shall have a reverse motion to the leaves, the track-tongues A and A′ are connected to the top o

Figs. 24.



Figs. 25.



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to be employed as facing points, such as at a single-line terminus.

It was originally proposed to convey the motion to track-tongues A and A′ through coiled springs, instead of the distance pieces U and U′ shown in the figure; but the proposal was abandoned in favour of the more rigid connection afforded by the latter. At several points on the route where the vehicular traffic is considerable, the points are operated from the footpath, motion being conveyed to the rocker J by means of the connecting-rod V. The angle-bars WW′, which support the track points, are also used for supporting the shafts. They are securely embedded in the concrete at the bottom of the pit, and are united by suitable bracing.

As the free end of the slot-leaves is tapered, the shank of the plough of a trailing car will gradually establish a passage for the plough, and it will be impossible for the latter to impinge against any sharp corner or other obstruction. Under normal conditions, one of the leaves will be always under the narrow tip of the slot-point, by which arrangement any extensive downward movement at this end of the slot-point will be prevented. All facing points, trailing points at car-sheds, and points of crossover-roads, are fitted with a complete set of linkwork, so that a car can be sent in any direction required. At the trailing points of junctions, connection of the track-points with the slot-leaves is not necessary, and is therefore dispensed with.

It will be seen from the illustrations that the slot-leaves are partly on the surface of the street and partly underneath other ironwork. The object of this is to secure a uniform slot of ¾ inch at the surface of the street. Had the leaves been kept at the lower level throughout, a gap of 2 inches would have resulted at the tip of the overhung slot-point. The back of the leaf is rack-shaped, in order to break up the space left at the back when the leaves are in their forward position; and, with the exception of two narrow stiffeners, there is a clear opening for débris to fall through into the pit underneath. Alongside the point-pits, a small concrete water-connection chamber has been formed, in which is coiled a wired hose with nozzle. With this the track and slot-points can be washed entirely clear of mud in a few seconds.

All the points and crossings were made by the Lorain Steel Company, of Johnstown, Pa., from what they term "special guarantee steel," with hardened centres at points of greatest wear. It was all fitted together carefully at their works, and the different parts were clearly marked. This has been of great assistance in

assembling the parts in place, and has enabled the work to be erected quickly and accurately. Serious dislocation of traffic at important street-crossings has thus been avoided.

From the cross section of the line (Fig. 2) it is apparent that, owing to the slot-rails being ⅜ inch higher than the track-rails, water on the surface between the two inner track-rails cannot flow to the side of the road. To carry off this water, track-rail drains have been fitted at all longitudinal dips, by cutting away about 12 inches of the groove of the rail and leading a pipe thence into the conduit at the sill-level. A cleaning-box is provided next the rail.

The material generally employed for paving within the tramway-rails has been granite sets (Figs. 2 and 5), but occasionally, in front of churches, hospitals, etc., less noisy paving has been laid. In tramway-margins wood or stone has been laid, to correspond with the existing paving in the breast of the road.

The paving-sets are laid on cement bedding (3 to 1), racked with ⅜-inch pea gravel, and rammed to a uniform height of ⅛ inch above the rail-heads. Two groutings were used: the lower, consisting of bitumen and a small quantity of oil, was poured into the joints hot until it reached within 1½ inch of the surface; the upper, of cement mortar (3 to 1) was swept into the joints until flush with the surface of the paving. It is important that the grouting with bitumen should be carefully carried out, as otherwise water would get into the joints, and in frosty weather closure of the slot might result. The object of the top grouting is to prevent the bitumen from rising to the surface in very hot weather.

Electrical Distribution.

It is intended to supply power to the greater part of the tramways in South London from a main generating-station—in course of construction—on the river-bank at Greenwich, in which there will be installed machinery suitable for generating three-phase alternating current at 6,500 volts, to be transmitted to transforming sub-stations in different districts of South London. Pending its completion, power is supplied to the Tooting lines from the South London Electric Supply Company's station at Loughborough, where two 1,500-kilowatt continuous-current sets have been erected for this purpose in a temporary building, and two boilers have been added to those in the Company's boiler-house, to furnish sufficient steam.

From Loughborough current is transmitted direct to the distributing switchboards at each of the three sub-stations, at the "Elephant and Castle," Brixton, and Clapham. From these switchboards current is taken to the various ½-mile sections (Fig. 1) into which the line is divided in compliance with the Board-of-Trade requirement for London.[1] In the final arrangement the current will be fed through the same switchboard, but by the transforming plant in the sub-stations, receiving current from the high-tension alternating-current plant at the Greenwich station. All that is required in the sub-stations at present, to provide for the working of the Tooting lines, is the distributing switchboards mentioned above. There are six distributing-panels at the "Elephant" sub-station, four at Brixton and nine at Clapham; approximately one for each ½ mile of track.

The switchboard-connections are arranged thus:—The main feeders from Loughborough are coupled direct to two bus-bars carried along the top of the feeder-panels. The positive outgoing distributors are coupled to the positive bus-bars through a maximum cut-out and ammeter, and the negative outgoing distributors to the negative bus-bars through an ammeter only. Each distributor is connected to a double-pole change-over switch, having two contact positions and a central "off" position.

By means of the change-over switches at the sub-stations, each ½-mile section of the line is so controlled that in the event of a fault occurring on the positive side of any section, the polarity of the distributor feeding the bars can be reversed, and the fault will thus be thrown on the negative side, where it can remain until the defective car is run into the shed, or until the stoppage of the car-service at night will permit the fault on the line-equipment to be located and rectified. The normal difference of potential of the conductors at the car will be 550 volts.

Figs. 29, Plate 3, show the standard construction adopted at the break between two sections. In the tramway margin next the footpath, on which the feeder-pillar is placed, a concrete pit is built, with ducts leading from it to the feeder-pillar and to the line. Through these ducts cables are drawn, to connect the conductor-bars in the conduit with the panels in the feeder-pillar; the method of connecting at the conductor-bars is shown in *Figs. 30*. The conductor consists of two bronze pieces bolted together; one piece is riveted to the conductor-bars with two ¾-inch copper

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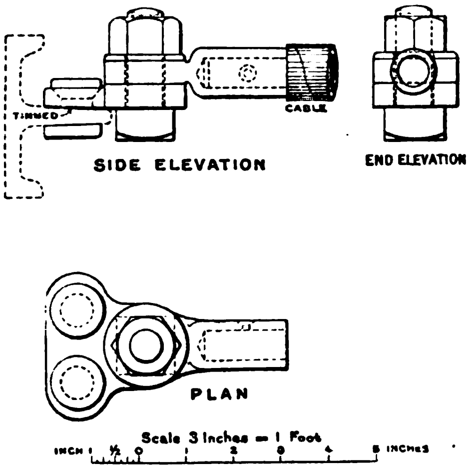
[1] Apparently this is not a rigid rule, as at Bournemouth one of the sections is ¾ mile in length.

rivets, and the other has a thimble into which the cable is sweated. The gap between the conductor-bars is 2 feet, the actual break of contact being 2 feet 9 inches; and it will be seen that the ends are flared to give an easy entrance to the plough.

With a view to strengthen the conductor-bars to take the shock of a plough impact, two insulated supports are placed at the pits adjoining the section-insulator, as shown in Figs. 29, and the conductor-bars are connected to the cables at this place.

At junctions and crossovers it is necessary to introduce various mechanical breaks in the conductor-bars, either owing to want of room, or else to give a free passage for the plough.

Figs. 30.



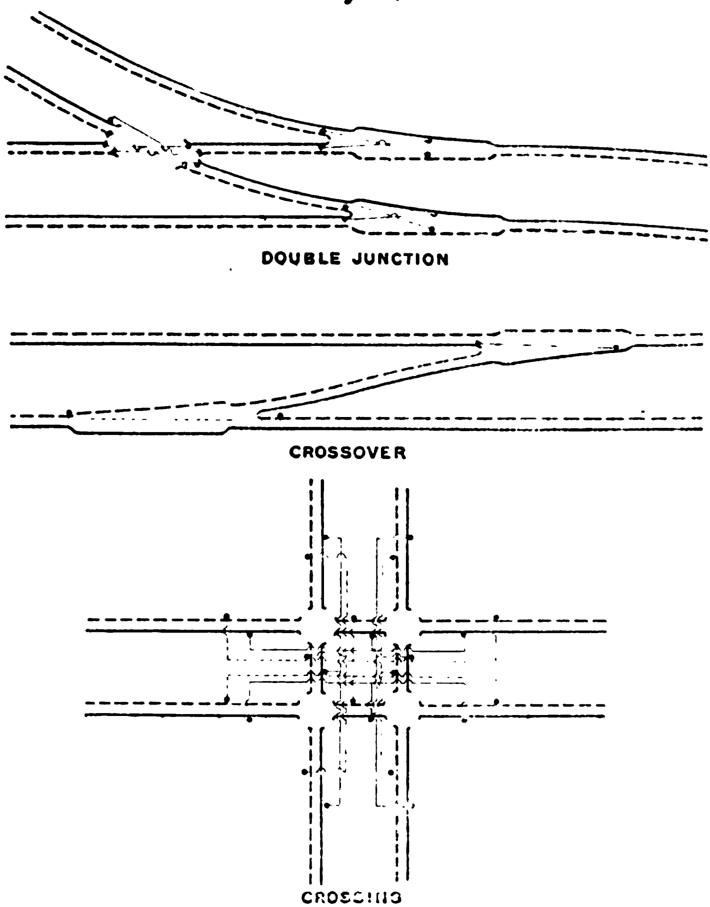
CABLE CONNECTOR TO CONDUCTOR-BAR.

Figs. 31 show diagrammatically the breaks that occur at a junction, a crossover road, and a crossing, with all electrical connections. These connections are made by cables laid in stoneware ducts with Stamford joints, and facilities are afforded by drawing-in boxes built outside the tracks. The longest break is 12 feet 6 inches, at a junction, and the shortest 2 feet, at a right-angled crossing. The effect of the short breaks will hardly be noticed; and in the case of the longer breaks, with a car travelling through points at a moderate speed—say, 6 miles per hour—there will be a slight flickering of the lights during the 1·42 second the car is coasting (or 1·06 second at 8 miles per hour).

Collection of Current.

The arrangement for collecting current from the insulated conductor-bars placed in the conduit, and for conveying it to the car-motors mounted on the trucks, is shown in Figs. 32 and 32a,

Figs. 31.



Conductor-Bar Connections at Special Work.

Plate 3. The part suspended from the truck into the conduit is called the "plough," and its support the "plough carrier." One complete collecting-apparatus is fitted to each car, and trap-doors

in the car-floor provide means of access to any part of the apparatus.

The details of the plough are shown in Figs. 33, Plate 3. It will be seen that the two soft cast-iron shoes, one on each side of the plough-shank, make contact with the conductor-bars. These contact-shoes are secured to the wooden framework at the bottom of the plough by hinged steel links and by a mild-steel flat spring. When the plough is not in use, and the springs are normal, the distance between the rubbing surfaces of the shoes is 7 inches, the links being arranged to prevent any further expansion. When the plough is in place between the conductor-bars, the springs are compressed, and the distance between the rubbing surfaces is reduced to 6 inches. A force of 8 to 10 lbs. is sufficient for this, and ensures enough pressure on the conductor-bar to establish good contact.

Short flexible fuses connect the shoes to the copper strip or lead running down the chase inside the plough-shank. These fuses are made of closely stranded copper wire, and each will blow at about 200 amperes. The fuses have a split-tube spring bayonet contact for fitting into the terminal at the bottom of the copper leads, and at the contact-shoes.[1] Both the top and bottom terminals of the copper leads are made of brass, sweated on to the leads. These leads are covered with rubber and taped, and the whole is carefully vulcanized. From the top terminal a cable of 0·064 square inch section is taken to the car-motors.

The bottom of the plough consists of three pieces of maple wood, held together by steel screws, and it will be seen from the illustration that each screw penetrates through two of the boards only. The heads of the screws are recessed into the wood, the recesses being filled up flush with a special insulating material.[2] Before the woodwork is put together it is immersed in a bath of this insulating composition, at a temperature of 150° F., for 24 hours. The shank of the plough consists of two mild-steel plates, tightly screwed together, and the chases for the copper strips are carefully milled out. The thickness of the plate, after the chase has been milled, permits $\frac{5}{32}$ inch to be worn off before renewal becomes necessary. The head of the plough consists of two gun-metal castings bolted to the shanks. The ends of the castings are designed

[1] At the bottom of the leads, the spring bayonet contact has proved sufficient to maintain the fuse in place, but at the contact-shoes, in order to overcome the loosening effects of vibration, it has been necessary to supplement this holding device by adding the spring shown in Figs. 33.

[2] Composed chiefly of beeswax, paraffin, vaseline and rosin.

so as to form a cross-head which bears on the bottom flange of the Z-shaped carrier. The claw-shaped steel casting bolted to the head of the plough enables the motor-man, by the aid of a special lifting-apparatus, to raise the plough clear of the track when required, for example, where the car runs on to an overhead system.

Every plough is tested, at the maker's works, with a 2,000-volt alternating current between both the plough contact-shoes and the steel plates of the plough; and a condition of acceptance is that it must stand this pressure for $\frac{1}{2}$ hour without injury. The completed plough is also immersed in the insulating compound before mentioned, but at a slightly lower temperature, for some hours, and on its being withdrawn, the waxy solution is allowed to dry thoroughly. The carrier (Figs. 32) has two side frames which are bolted to the side frames of the maximum-traction truck at the pedestal of the small wheels, and form an extension to it. Between these extension members are two Z-shaped cross-bars, 5 inches by 3 inches by $2\frac{3}{4}$ inches by $\frac{5}{8}$ inch, from which the plough is hung. The plough rests on the bottom flange of the Z bars, and an angle-iron bolted to the web of the bars prevents the plough from rising (Fig. 32*a*). The ends of the bars are left open, so that in an emergency, such as taking the wrong road, the plough, after travelling right across the carrier, can drop out of the guides at the ends without any serious damage. By this means the most fruitful source of damage to ploughs and interruption to traffic is avoided. In order to allow a plough to slide easily on these bars, the bottom bearing of the plough-head is rounded. In the centre of one of the Z cross-bars a space of 8 inches of the bottom flange is cut away, and a substitute for it is provided by a hinged flap (Figs. 32*a*). This flap is secured to proper level by the bolt shown in Fig. 32. The object of this arrangement is to provide a ready means for removing or inserting a plough while the car is on the line. All that is necessary to accomplish this is to release the hinged bearing by withdrawing the bolt by means of the handle A. The hinged flap then drops, and the plough can be removed or inserted as desired. The rubber cables from the ploughs to the motors have suitable plug connections for permitting a plough to be disconnected when it drops off, or is removed from the carrier.

Description of Road-Work Operations.

It is a matter of the highest importance in all such operations as tramway work, which cause extensive disturbance of street-surfaces and consequent interruption of vehicular traffic, that they should

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disturbance of the street. The diversion
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at, in towns situated like London, the restrictions
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The restrictions make trenching a difficult and
ntractors, to whom no guarantee can be given that
yond 100 yards; and they are apt to be used by local
lever to secure concessions from the County Council

of the work, except where their removal at that time would have occasioned serious interference with the horse-car service. In all, about two hundred obstructions were met with, ranging from small service-pipes to 3-foot iron mains, and still larger brick sewers. They included gas-, water-, electric, telephone- and telegraph-mains, sewers, sewer-manholes and ventilators.

At the Tooting end, where the re-construction operations started, three 30-inch water-mains run practically underneath the tramway all the way from the terminus to Devonshire Road, a distance of over $1\frac{1}{2}$ mile. As these pipes for a considerable length were 1 foot 6 inches to 2 feet 6 inches below the surface, it required some manœuvring of the line to avoid diverting them. Before fixing the position of the new line here, the position and depth of the pipes found in the numerous trial openings were carefully recorded on a large-scale plan prepared from an actual survey. The lines were then schemed out in the positions where they were most likely to avoid the water-pipes. It was not, however, found possible everywhere both to secure a good alignment of track and to avoid the pipes; and a scheme for raising the roadway at several places was submitted to the Wandsworth borough authorities and was agreed to by them. This method of dealing with pipes was subsequently followed at a number of other places, and considerable expense and delay to the works were thus avoided.

Where obstructions have been encountered running for a short distance along the conduit-track at a depth of 2 feet to 2 feet 6 inches, the difficulty has been overcome by using cantilever yokes (Figs. 34, Plate 3). Elsewhere, obstructions met at the same range of depth, but crossing the track at right angles or nearly so, have been avoided by altering the spacing of the yokes, so as to bring the obstruction into the panel between them. In such places an inverted trough, for protecting the part of the pipe entering the concrete construction, was fixed when required. The upper part of the cantilever yoke is the same as the standard yoke so far as the bearing surface of the slot-rail and the anchoring lugs for the tie-bars are concerned. This allowed the standard arrangement of erecting the track- and slot-rails to be adhered to. One drawback to the use of the cantilever yokes is the delay that occurs in fixing them in position, the final erection and adjustment having to wait until the track-rails are in place; and another disadvantage is that less control of the slot-opening is obtained. Nevertheless they have been the means of effecting a considerable saving of expenditure in pipe-diversions, and no bad effects have resulted from their use.

Although pipes and other mains have been allowed to penetrate the 6-inch concrete sill of the conduit, no sufficient reason arose for allowing them inside the conduit; and in the point-mechanism pits the linkwork has been designed so that no part crosses the line of conduit above the sill-level. By this arrangement no restrictions will be imposed on the operating department when periodically cleaning out the conduit. For the scraper there will be everywhere an available height of 8 inches from the sill of the conduit to the underside of the conductor-bars.

The lines and levels having been fixed provisionally, and all the larger ascertained pipe-obstructions having been removed, the work of laying the temporary track, necessary for the accommodation of the very frequent horse-car service during reconstruction, proceeded. The day car-service, lasting from 7 A.M. to 1 A.M., varies considerably on different sections of the route. In some parts a car runs each way every minute, and in other parts the interval is only ½ minute. At St. George's Circus, where many lines converge, five hundred cars per hour were run over one piece of temporary track. Between the hours of 1 A.M. and 7 A.M. a small service was maintained over the greater part of the line. The course usually followed was to attack one line at a time, and to use the other line, supplemented with long loops of temporary track laid alongside on the surface of the street, for the car-service. Most of the loops or double-line portions were about 500 feet in length: the single-line portions rarely extended to 400 feet. The car-service on the temporary lines was regulated by signal-posts, with semaphores painted red and white by day, and red and clear lights at night.

The section of rail adopted for the temporary lines was of the flat-bottomed type with bevelled sides. On straight parts at intervals of 24 feet, and on curved parts at intervals of 12 feet, flat steel tie-bars were spiked to the roadway, and kept the track to gauge. When laid in position, the rails were barely 2 inches above the surface; and, in order to enable the ordinary vehicular traffic to pass over them more easily, wedge-shaped wood and bark were laid along the sides of the rails at short intervals. This form of temporary line is easily laid, and offers little obstruction to traffic; and the infrequency of accidents testifies to its suitability.

The old permanent way had been laid at different periods extending back to 1869, and it varied somewhat in character. The condition of the old concrete bed also varied considerably. The depth of the concrete bed ranged from 5 inches to 18 inches. The old paving was chiefly of stone, grouted with cement. The best of the old sets were redressed and used in the new work.

The first operation in breaking up the old permanent way was to lift the paving in the margin of the track undergoing reconstruction, cut out the concrete underneath, and dig small pockets at intervals of 3 feet. Into these pockets Barrett jacks, commonly called "pump" jacks, were placed with their toe-piece underneath the track concrete. Each of the jacks was capable of lifting 15 tons at either head or toe, and by their aid the whole mass of track-paving, rails and concrete bed was lifted.[1] After the roadway had been raised to the required height—about 6 inches at the jack end—sleepers and old sets were placed underneath the raised track to take the weight, and the jacks were moved forward another stage. Where the old concrete bed was sound, a trench only was cut for the conduit. In this case the jacks were inserted underneath the rails, and the strength of the cement jointing of the sets was usually sufficient to permit of the paving being lifted in large masses. Sometimes as much as 300 lineal yards of single line were lifted in one day; and the waste due to breakage in separating the old sets was much less than would have been the case under ordinary breaking up. It was found that lifting with the jack shook the paving considerably, with the result that the stones were loosened more readily.

After the required extent of the old concrete had been removed, a trench was dug for the conduit, in width not less than 2 feet 2 inches, and widened out every 5 yards to 3 feet 8 inches for the insulator-pits. Pockets were cut every 3 feet 9 inches to accommodate the concrete backing and foundation for the yokes. The yokes, with the slot-rails securely fastened to the yoke-seats and their tie-bars fixed loosely, were next placed in position. The slot-rails, with yokes attached, were then brought to proper alignment and level, and were supported in that position until the concrete had set, by sleepers or channel-bars laid across the trench underneath the slot-rails, in alternate bays. The first concrete to be laid was that beneath the yokes. Before inserting it, all loose material was carefully cleaned out of the pockets, and the depth for concrete was gauged. The concrete for the yoke-foundation was kept very stiff, and was thoroughly packed by men standing on both sides of the yoke, who worked the concrete in with a special packing-tool, in shape like a long spade with a narrow blade. After this was done, the centering was inserted in the bays with no temporary supporting cross-beams. This centering consisted of two side pieces of the same contour as

[1] Hydraulic jacks were used at first, but were abandoned owing to over- caused by the difficulty of regulating the work done by each jack.

the inside of the yoke, and one wedge-shaped centre part which was driven down between the side frames, jamming them tightly against the inside face of the yokes.

Simultaneously with the concreting of the tube, the concreting of the insulator-pits proceeded, a separate centering gauged off the slot-rail being provided for each. When the general concrete had been allowed sufficient time to set—usually 36 to 48 hours—the centering was loosened and run along the tube to the open end, or to special openings left for the purpose, where a 7-foot 6-inch piece of slot-rail had been detached, and there it was taken out.

Following on the completion of the concrete tube, the paving-base concrete was proceeded with. This was laid of not less depth than 8 inches, and consisted of Thames ballast and cement in the proportions of 7 to 1. The concrete for the paving-base was mixed on the site, the mixing platforms being moved forward to suit the operations. The concrete for the tube, however, was mixed in rather a novel way, which had the effect of keeping the main roads, where the tramway construction was proceeding, comparatively free from concrete materials. Thereby greater facilities were given to vehicular traffic, and a clear way for bringing forward the rails, etc., was provided. All the materials were stored in the side streets, where they were put into "dromedary" mixers which mixed them on the way to the scene of operations. A "dromedary" mixer consists of a cylindrical drum, holding about $\frac{3}{4}$ cubic yard of concrete, mounted on an axle on which the travelling wheels are fitted loose. By connecting the drum to a pawl and ratchet arrangement, the drum can be made to rotate with the wheels when desired, and a hinged trap-door is provided which throws the pawl out of gear by means of a pin attachment.

As soon as the concrete base was sufficiently firm, the track-rails were laid. For curves of 100 feet radius and upwards they were jim-crowed on the site, this work being done before bringing the rails forward from the side streets. For curves of smaller radius the rails were sent to a shop, and there bent as required. A considerable amount of fresh holing in the rail-webs was necessary, largely owing to the position of the tie-bars being determined by the spacing of the yokes. Of course, twice as many fresh holes are required in a conduit track as in an ordinary track. This work was performed by hand-drills, or by hydraulic punching-machines, the latter doing three times the work of the former.

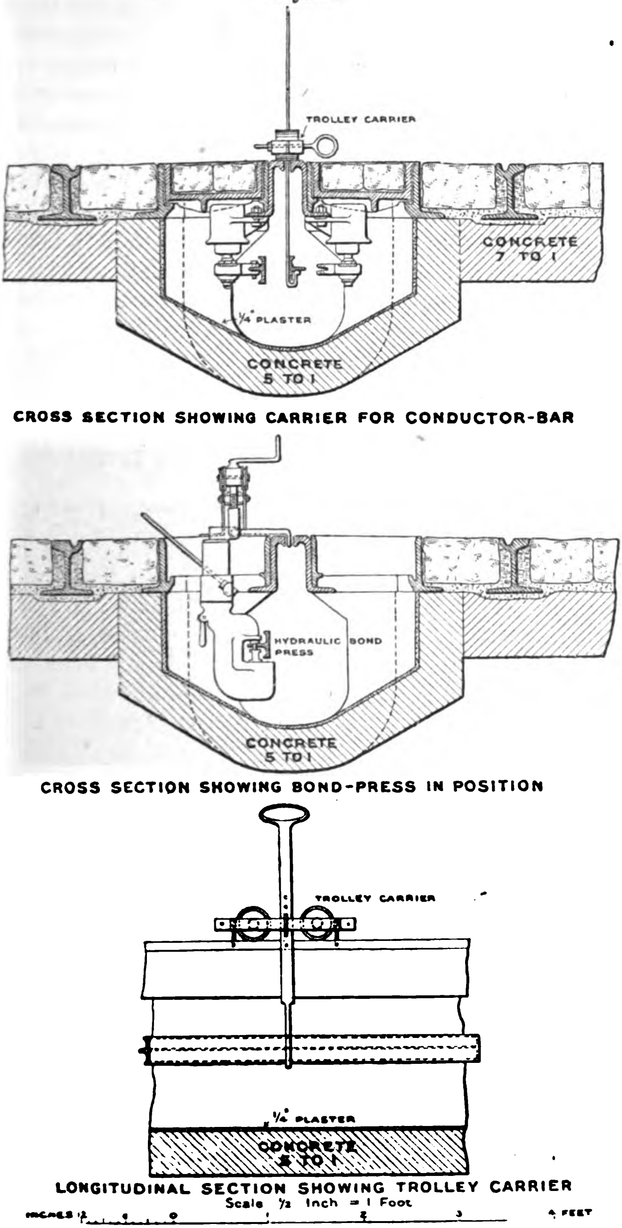
The next operation was the rendering of the insulator-pits and the inside of the conduit with cement mortar (3 to 1). Hand-trowels were used for the pits, and a special detachable brush was used

for sweeping a thin layer of cement mortar along the inside of the tube. The insulator pit-frames were then laid in position on a prepared bed of cement mortar, and the top of the frame, fixed in position to the same camber as the paving, was allowed to project $\frac{1}{16}$ inch above the plane of the rail. The paving in the covers was laid slightly higher, so that its surface might correspond with the general paving, kept $\frac{1}{8}$ inch above the slot- and track-rails. After the frames had been set, a layer of cement mortar was spread round all the frame-edges and along the slot-rail flange, so as to seal up effectually any small hole where the concrete had fallen away.

The conductor-bar gang then commenced their work. No curved bars were allowed into the tube until they had first been checked by laying them on the top of the slot-rail immediately over the place where they were to be fixed. The bond-holes at the ends of the conductor-bars, which were originally drilled at the rolling-mills to a bare $\frac{3}{4}$-inch diameter, were then rimered out to a full $\frac{3}{4}$ inch, and the cylindrical solid terminals of the bonds were inserted in one end of each conductor-bar. There the terminals were expanded into the holes by the hydraulic bond-compressors shown in *Figs. 35*, capable of exerting a pressure of 15 tons. Several conductor-bars were sawn through the holes with the bonds in place, and the results were remarkably good. The conductor-bars, having been thus prepared, were introduced into the tube at openings every 200 yards, where pieces of slot-rail 7 feet 6 inches long, *i.e.*, spanning two bays, had been left out, and were carried on hooks attached to small trolleys running on the slot-rail (*Figs. 35*). The conveying arrangement is very simple. Each trolley-carriage consists of two rollers the axles of which support two cross-bars. Between these, a holed flat bar is suspended at any height, by inserting a pin through it and the cross-bars. This bar hangs between the slot-rails, and is hooked at its lower end, to carry the conductor-bars.

The conductor-bars having been brought into place at the correct height, the work of fixing them to the special insulator-supports then proceeded. This was done by fixing the cast-iron clips, loosely threaded on the insulator-rod, on to the conductor-bar by means of the tapered pin. The attachment to the insulated support was then made by screwing on the bottom nut. The fixing of the free ends of the bonds was done in the tube by means of the hydraulic bond-compressors. The press was inserted into the inspection-pits, and suspended from a stand spanning the pit (*Figs. 35*). Once in position over a bond, the press was jammed tightly in place during the bonding-operation by means of a crank and screw. Pressure was applied to the water in the cylinder by

Figs. 35.



APPLIANCES USED IN ERECTION OF CONDUCTOR-BARS.

hand-levers arranged to suit an operator working the lever from the road-surface. The top of the bond-compressor was stationary, the lower part carrying the ram for pressing the copper terminal against the conductor-bar. The whole apparatus weighs about 110 lbs., and can quite easily be worked in the confined space available.

The paving sets are laid with their surface $\frac{1}{8}$ inch above the rails. As already remarked, the slot-rails are kept $\frac{3}{8}$ inch above the track-rails. This has been found to give sufficient fall in the paving to drain the bulk of the water away from the slot.

Cost, etc.

A statement of the cost of the conduit construction is given in Appendix I. For comparison the Author has added in Appendix II. particulars of the cost of conduit construction in Edinburgh, for cable traction.

Dr. Alex. B. W. Kennedy, Vice-President Inst. C.E., has been the Engineer to the work throughout. The preliminary stages in connection with the Parliamentary work and specifications in the office were in the hands of Mr. Roger T. Smith, Assoc. M. Inst. C.E.; the Author, assisted by Mr. F. B. Sonnenschein, Assoc. M. Inst. C.E., and by Mr. P. L. Riviere, of Messrs. Kennedy and Jenkin's staff, took charge as Resident Engineer for Dr. Kennedy when Mr. Smith left for Buenos Ayres just before construction commenced.

The contract for the road-work was given to Messrs. J. G. White and Company, Limited, whose Chief Engineer, Mr. A. N. Connett, M. Inst. C.E., has had very large experience in conduit-tramway construction abroad, experience which has been of the greatest value during the work. Messrs. J. G. White and Company's Superintendent on the works has been Mr. A. H. Fisher, and the work of paving and laying the concrete base and sewer-connections has been sub-let by them to Messrs. William Griffiths and Company, Limited.

All the rails and fastenings have been supplied by Messrs. Walter Scott, Limited, of Leeds.

The rolling stock has been made by Messrs. Dick, Kerr and Company, Limited, and Messrs. J. G. White and Company have been their sub-contractors for the plough-equipment, the ploughs themselves being essentially to Mr. Connett's design.

The Paper is accompanied by drawings from which Plates 2 and 3 and the Figures in the text have been prepared, and by the following Appendixes.

APPENDIXES.

APPENDIX I.—SOUTH LONDON TRAMWAYS.

Cost of Electric Conduit Construction.

—	Total Cost of 16·4 Miles of Single Line.	Cost per Mile of Single Line.
	£	£
1. Permanent-way construction, including road-work, paving and special work[1]	220,750	13,460
2. Street improvements and alterations	2,200	134
3. Cables and feeder pillars	37,750	2,301
	260,700	15,895
4. Power-stations,[2] sub-stations, car-sheds and plant— Buildings £39,630; Plant 24,870	64,500	3,933
5. Cars (6·1 per mile of single line)	71,550	4,363
6. Supervision and incidentals	15,000	915
Total	£411,750	£25,106

[1] This item includes £7,500 for obstructions = £458 per mile of single line.
[2] Temporary station only at Loughborough Junction.

APPENDIX II.—EDINBURGH CORPORATION TRAMWAYS.

Cost of Cable Conduit Construction.

(The figures embrace the cost of all the lines recently constructed by the Corporation with the exception of the Mound and Lauriston routes, which are worked from a depot built prior to the acquirement of the lines by the Corporation.)

—	Total Cost of 35 Miles of Single Line.	Cost per Mile of Single Line.
	£	£
1. Permanent-way construction, including road-work, paving and special work[1]	505,100	14,431
2. Street improvements and alterations[2]	31,150	890
3. Cables	7,750	221
	544,000	15,542
4. Power-station, car-sheds and plant— Buildings £192,000; Plant 87,800	279,800	7,994
5. Cars (4·1 per mile single line)	62,300	1,780
6. Supervision and incidentals	35,000	1,000
Total	921,100	26,316

[1] This item includes £16,753 for obstructions = £478 per mile of single line.
[2] A considerable part of this sum was ultimately paid by the City as representing permanent street improvements.

Discussion.

The Chairman. The CHAIRMAN moved a vote of thanks to the Author for his valuable and practical Paper.

The Author. The AUTHOR exhibited a number of lantern-slides showing various operations in the re-construction.

Mr. Benn. Mr. J. W. BENN, Chairman of the Highways Committee of the London County Council, was glad to have an opportunity of expressing, from the layman's point of view, the obligation of the County Council to the able engineers who had carried out so successfully such an intricate piece of work. When approaching the matter of electrifying the tramways of London, the Council had been brought face to face with a grave responsibility, and they had been extremely fortunate in securing Dr. Kennedy as their guide and counsellor. Mr. Benn could not help remembering the storm of criticism which had been directed against the earlier proposals for the work. When Dr. Kennedy presented his first report, referred to in the Paper, technical, financial and other critics had declared that the system was costly, that it would not work, and that it would be a gigantic mistake, on a par with other mistakes made by the London County Council. It was therefore with great satisfaction that he came to that meeting fresh from the inspection of the second section by the Board of Trade, and having in his memory the gratifying opinion of Colonel Yorke with regard to the efficient and satisfactory nature of the conduit system. The citizens of London were grateful for having secured, at all events for the centre of London, a system which was working perfectly nd to the satisfaction of the passengers, and which had saved e streets from disfigurement by the poles and wires which had, his judgment, ruined the appearance of many towns and cities. course, as Dr. Kennedy had said in his report, for outlying tricts it might be necessary, for economical reasons, that the rhead system should be adopted. No doubt it had the great vantage of economy.

Mr. MAURICE FITZMAURICE remarked that he had in some ways ught up Dr. Kennedy's cloak with regard to the road-work n connection with the further reconstruction of the London cil tramways for electric traction. Since the opening es of line described in the Paper, about 31 more

miles of track had been reconstructed by him in South London at a cost of something over £400,000; so that the work of reconstruction was making rapid progress. He was therefore in a position to appreciate the careful way in which the Paper had been prepared, and the amount of descriptive detail which it contained. His work had been greatly lightened by Dr. Kennedy having borne the heat and burden of the day in the earlier stages of the reconstruction. The Author referred to the borough councils as having power not only to veto any system of electric traction which they did not consider satisfactory, but also to require the plans of the road-work to be submitted to them for approval. Had Dr. Kennedy foreseen what that meant, he might, perhaps, have followed more closely the broad principles laid down by him and mentioned in the Paper, namely, that while in the great central zone of London, where there were many junctions and crossings of a complicated character, the open-slot system should be constructed, in suburban and semi-rural districts, where there were for the most part broad straight streets with few junctions, the overhead system should be adopted. In Mr. Fitzmaurice's opinion the streets in which the conduit system was required, according to these principles, extended from the Thames bridges to Kennington Park; beyond that point he thought the overhead system might have been adopted. However, the conduit system had been adopted throughout the Tooting lines, and the effect, in regard to the veto which the borough councils had as regarded systems of traction, was that, having had the good wine to begin with, the borough councils now refused to have any other brand: they wanted the conduit system everywhere. He had not a word to say against the conduit system, and if money were no consideration, and inconvenience during reconstruction for electric traction was cheerfully borne by the public, he would put down a conduit line always. But it had to be remembered—and it was well to keep the fact clearly in view—that there were certain disadvantages connected with the conduit system; the chief of these were higher cost, more inconvenience to the public during reconstruction, and less flexibility compared with the overhead system. With regard to cost, he thought it might be taken that, under the best conditions, the conduit system in London cost £7,000 more than the overhead system, per mile of single track. That figure might in some cases be largely increased, if a considerable amount of bridge-work had to be reconstructed, or if many water-mains and gas-mains were met with. Recently, when in New York, he enquired as to the view held there in regard to the difference in the cost of Mr. Fitzmaurice.

Mr. Fitz-maurice. the two systems, and he found it was considered to be never less than £10,000 per mile of single track. He thought that figure might fairly be compared with £7,000 or £8,000 in London, because the rates of wages in New York were considerably higher than in the metropolis. If all the lines in London, authorized and constructed, were built on the conduit system, they would cost considerably more than if half of them were built on the conduit system and the other half, in the suburbs, on the overhead system: the difference would be nearly £1,000,000. London could well afford to have a conduit system over a large area, but in some parts it was possible to have the overhead system. The interference with traffic during reconstruction was certainly greater than in the overhead system, particularly if long lengths of mains had to be diverted and bridges to be reconstructed. An endeavour had been made to minimise this inconvenience as far as possible, by getting the work done during the six or seven summer months; because then the days were longer and the weather finer, and the work could be accomplished fairly quickly. As the Author mentioned, the borough councils could insist on the work being carried out in 100-yard lengths, but he was glad to say they had not done so. It was found that more interference with the general traffic was caused when a number of 100-yard lengths were being reconstructed simultaneously over a district, than when a long length was handed over to the contractors. The ordinary tramway traffic had to be carried on all the time, and the trams ran on a temporary track laid on one side. The greater the number of separate lengths under reconstruction, the greater was the number of crossings from permanent to temporary track; and it was those crossings which interfered so seriously with the road traffic. Really, the least inconvenience was caused by having the longest possible length of temporary track without crossings. In the Brixton cable-line, the contract for whose reconstruction would, he hoped, be let during the next few weeks, he proposed to have, if possible, a temporary track the whole length of the route, and to hand over one of the permanent lines altogether to the contractors for the reconstruction work. That would do away with the objectionable crossings. The disadvantage of the conduit system in respect of want of flexibility applied particularly to making new lines connecting with a conduit line already made, and also in many cases where only a single line could be constructed in the first instance, on account of the narrowness of the street, to widening that line at a future date. Where current was taken f... an underground conduit, it was obviously difficult, when

Mr. Fitz-maurice.

altering the track, to run on a temporary track, as current could not be picked up through the plough. The overhead system was not affected in that way, as the current could be picked up from the overhead wire just the same by cars running on the temporary line. The difficulty could of course be overcome, at some expense and trouble, either by putting up a short overhead length and wiring the cars to take current in that way, or by using two or three cars fitted with accumulators, for hauling the cars past the short length which was being reconstructed. New connecting lines were, as a rule, made in the suburbs, and that was another reason for constructing the suburban lines, at all events in the first instance, on the overhead system. On account of the difficulty of connecting new lines to a conduit line after it had been made, it had been customary in some places to put in the special work for future connections—connections which would be wanted 2 or 3 or perhaps more years later—so as to avoid interfering with the conduit at a later date. Unless such connections were going to be made within a comparatively short time, it was an unsatisfactory plan to put in the special work, on account of its limited life. At an ordinary junction such work cost about £900; and if the line for which it was put in were not made for some years, the special work might be worn out before the connecting line was constructed, and then the money would be wasted. It was extremely difficult to fix the life of special work; but from some enquiries he had made in New York, where there was a large system of conduit tramways, he had found that under heavy traffic such work would not last more than 7 or 8 years. Manganese steel would have a much longer life, but he had not had sufficient experience of that. Some makers had been asked to guarantee the passage of two million cars for special work, and they did not see their way to do it. Two million cars with a 1-minute service for 18 hours a day, meant a life of 5 years; but he thought special work under such conditions would last much longer than that. The special work for the Tooting lines had come entirely from the Lorain Steel Company of America, but for later work it had been divided between that company and Messrs. Hadfield. An endeavour had been made to devise some more satisfactory arrangement for the slot-points than that adopted in the work under consideration, and both Messrs. Hadfield and the Lorain Company had at his request devised some arrangements which he thought would probably be an improvement, and which would not be so liable to give trouble. It would be noticed that in nearly every case granite pavement had been used in the tracks.

Mr. Fitzmaurice. The principal reason for that was that the expansion of wood pavement was very liable to close the slot. With a $\frac{3}{4}$-inch slot and a $\frac{5}{8}$-inch plough there was very little room to spare. He had had some sample lengths of different kinds of paving put down, and had found a very strong tendency to close the slot. Mr. Kirkaldy had made some experiments for him to ascertain the actual force required to close the slot, and those might lead to some little alterations in design which might possibly be helpful. The decision as to whether a centre or a side slot should be used for any given line was important, and had a bearing on the question of the kind of paving to be adopted. A side slot must be 1 inch wide, to carry the flange of the rail; and then there was no question of wood paving closing the slot, because the flange of the rail tended to keep the slot open. In any case, with a 1-inch slot and a $\frac{5}{8}$-inch plough there was a margin if a little closing did take place; whereas with a $\frac{3}{4}$-inch slot there was practically none. The side slot had many other advantages over the central slot, but there was one objection to it, namely that hitherto it had been necessary always to bring the slot into the centre at special work. He had not been able to find a way of avoiding that difficulty, but he thought that Mr. Connett, who had done so much for conduit tramway work in London, could produce something when the right moment came. He really could not see any serious objection to a 1-inch slot; there were several places where it was in use, and he had not been able to find out any case of accident. He did not see why a central 1-inch slot should not be allowed in London; and if that were done, all difficulty with regard to the expansion of wood paving would be removed.

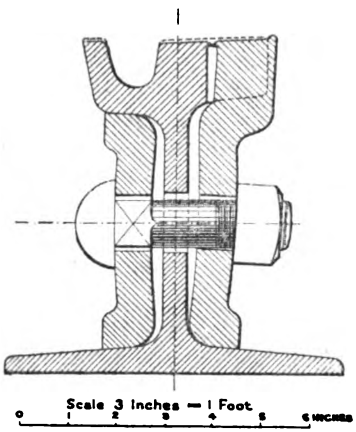
Mr. Rider. Mr. J. H. Rider observed that, since the opening of the line in May, 1903, about 8 months' experience of its running had been obtained; and, under the supervision of the County Council's staff, an additional 20 to 30 miles of single track had been constructed. He might perhaps be allowed, therefore, as the engineer who had to work the line, to state the experience gained, and to point out in what way the features of the earlier work had been departed from in laying down the later track. The paving-plates which ran from yoke to yoke in order to keep up the edge of the concrete were of great service, but unfortunately when an insulator-box was reached, the paving-plate was not carried across, probably owing to the physical difficulty of taking it across a box in which an open space was desirable. The result was that in many cases the concrete corners of the box had broken off and fallen down behind

Mr. Rider.

the conductor-bars. They were troublesome to locate, and a great nuisance until they were located, as they caused serious leakage from the bars. If some means could be devised for putting these paving-strips round the box, it would be a good thing for future work. According to the Author's statement, it was very difficult indeed to get anything down through the slot so as to touch the conductor-bars. But there was before the members a bundle of iron, consisting of boys' hoops, perambulator wheel-rims, and other things, which had been taken out of the slot, and had all caused short circuits. Unfortunately, a person could put such articles down the slot without receiving any injury, because it was not possible to reach the conductor-bars without making a good earth on the slot-rail. That safeguarded the person who put something down—but it interfered with the working of the tramways. As to the possibility of using a shallow conduit in certain places, such as in going over bridges, on the new lines, which had been inspected by the Board of Trade on the previous day, there were four bridges to be crossed, and in each case a shallow conduit had had to be put in. The result was that the bottom of the conduit was so close to the conductor-bars that cleaning had to be a daily operation. A very slight accumulation of water or mud was liable to get on to the bars and cause serious leakage of current. Such difficulties had to be met in practice, and the only way seen at the moment was to have a shallow conduit and to clean it frequently. In Figs. 17 and 18, Plate 2, were shown cross sections of the two types of track-rail, for straight roads and for curves, respectively. All the track-rails used on the Tooting lines were 30 feet in length, but on the new lines they were 45 feet, which had the effect of reducing the joints by one-third; and he was glad to hear that Mr. Fitzmaurice was about to try 60-foot rails. Every one who had to do with track-work knew that the joints were the chief trouble; and if they could be done away with altogether, the track would be almost perfect. There was some trouble with the joints on the Tooting lines, and there was likely to be more. The joint used was that commonly called the "Dicker" joint, shown in Fig. 17. Part of the head of the track-rail was cut away, and one of the fishplates was carried up to the head of the rail, so as to form a running-surface for the car-wheel. That particular fishplate had absolutely nothing to do with taking any of the weight of the rail, because the whole of the fishplate was carried up through the head of the rail, and it was only a four-hole fishplate about 2 feet long. One of the results of that type of joint was that the fishplate, which under normal conditions was tightened up by the bolts, and

Mr. Rider. lay against the head of the rail, was now showing signs of leaving the rail at the top. It was not so noticeable on the surface, as apparently the hammering effect of the wheels burred the edges of the rail and the fishplate. It was caused by the bolts giving, and the effect was something like what was illustrated in *Fig. 36*. If those fishplates had been extended under the head of the rail, with an ordinary fishplate on the other side, the joint would have been better. On the new lines that type of fishplate had been given up, and the ordinary pattern had been adopted on either side of the web, an anchor-plate, consisting of an inverted piece of rail riveted to the bottom flange, being put under the joint. Such a joint was quite rigid, but even with it a difficulty had arisen. On account of the variations in the rolling of the rails it was not possible to get lengths taken indiscriminately which were of exactly the same depth. When a sole-plate was put under the joint and riveted to the flanges, the bottoms of the adjacent rail-ends were brought exactly into line; consequently the least variation in the depths of the two rails, due to differences in rolling, showed itself at the head, and was enough to start a slight hammering action under the traffic, which became worse. The only remedy was to grind the heads perfectly flat with a portable grinding-tool after the joint had been made and the sole-plate put on; that gave a perfectly good running-joint. With regard to the system of drainage adopted on the Tooting lines, it would be seen that the left-hand conduit was connected by a pipe to the right-hand conduit, and that both drained into a sump. If water alone had to be dealt with, that was satisfactory; but when dealing with mud it was not so. The secret of success in conduit working was to keep the conduit perfectly clean, and for that purpose a mechanical scraper had to be used. When the scraper was drawn along the conduit, it was found that the dirt simply fell in front of the scraper into the mouth of the pipe and lodged there, and in order to remove it men had to go into the sump and work it out with a rod. Efforts had been made to get a different

Fig. 36.



Mr. Rider.

design of sump-pit adopted, but without avail. On the new lines the pit was larger, and extended from conduit to conduit between the tracks, with a fall of several feet immediately beneath the tube; so that when the mud was scraped along it fell into the pit and could be got out without difficulty. Even yet, it might perhaps be necessary later on to modify some of the original pits, owing to the difficulty of getting rid of the mud. He thought the new type of slot-point mentioned by Mr. Fitzmaurice was a great improvement on the older type. One of the early troubles had been caused by the ploughs fouling the slot-point when used as a facing point; but the whole of that trouble had been got rid of by a little severe treatment of the pointsman, because in all cases it had been found to be due to his carelessness in not bringing the point hard over. The plough went on and met the projecting end, and chaos resulted. One of the difficulties with the conduit sump-pits was the danger of flooding. On three occasions in the past year traffic on certain sections had been stopped on account of the conduit becoming full of water. In two of these cases there had been no default in the cleaning, the flooding being due to very heavy rain in the neighbourhood of Balham: the sewers had backed up, and the water had come entirely over the road, and so had filled the conduit. At that time it was not certain that it was not possible to work the line even with the conduit full of water; but those troubles had proved conclusively that it was not possible to keep the circuit-breakers in with the conduit flooded: and indeed it was evident that with ½ mile of road and two conductor-bars 6 inches apart, and about 3½ inches in depth, the resistance from bar to bar was so small that the current which passed was very heavy indeed. On the third occasion the trouble had been caused by the choking of a sump-pit in Westminster Bridge Road, whereby the conduit had been flooded again for a short time. The arrangement of the section-insulators, illustrated in Figs. 29, Plate 3, occurred every ½ mile, and it would be noticed that the ends of the conductor-bars were about 2 feet apart, in order that the plough should break contact with one section before making it with the next. That was necessary because there were means of reversing the polarity at each ½-mile section, in order to keep any leakage on one side of the electrical system. Pipes were laid from the box at the side of the track to the insulator-box next the rails, and through these pipes the cables were taken. One of the difficulties with the boxes was that they were too small. There was a double insulator in each box, and the pipe came up in the corner; the result was that, with a cable 0·25 square inch in area having

Mr. Rider. to be brought through that pipe and then connected to the bars, there was very little space in which to bend the cable and make a proper connection. That difficulty had been found out after the job was done, and care was being taken to avoid it in future work. The schemes of electrical connections shown in *Figs. 31* were not the first schemes got out; they were those ultimately arrived at, and their effect was that, whichever way the car was travelling, the polarity was not reversed. If the car came along the bottom road in the double-junction diagram and kept on the straight, the polarity was the same at one end as at the other, and if the car took the junction-road the polarity was also the same. In the diagram of the connections at a crossing, the conductor-bars were shown actually crossing. Those bars, however, had not been put in, and no trouble had arisen from having to jump from one side to the other without current. He thought the engineers had been well advised in leaving out those short lengths of conductor, because they would complicate the connections very much. The breaks between the conductor-bars at junctions and crossovers, however, were considerable. At a double junction there was a break of about 12 feet, and the car had to travel that distance by its own impetus. It was not possible to reduce the break, on account of the necessity of keeping the positive and negative bars at the far side of the junction separate from each other, and of providing a way for the plough to pass in either direction. But one bad effect of the break was, that the car-lights went out for quite an appreciable interval as the car passed through the junction; and should the car happen to stop at the junction, it could not move again until it was pushed either by hand or by another car. Many suggestions had been made for getting over that trouble, the most common being to employ two ploughs, one at the front of the car and one at the rear, the front plough making contact before the last plough broke contact. His own experience however, was that one plough was more than bad enough; and quite apart from the trouble of having to work two ploughs there was one objection which made that plan impossible. As already mentioned, the polarity in every ½-mile section was reversed from time to time, in order to keep earths on one side of the system; and with two ploughs set so that one entered one section before the other left the section in the rear, if the front section happened to have the polarity reversed, there would be a dead short circuit when the car took that section. For that reason it was quite impossible to use two ploughs. However, the difficulty with regard to stopping at those places was no longer felt

as the drivers had gained experience; and there was no trouble in coasting through the breaks, unless an omnibus blocked the way, as they sometimes did, at such a spot as the "Elephant and Castle," where there were more breaks than conductors. The weak point of the whole system was the plough, which was responsible for 95 per cent. of all the trouble met with. There was no difficulty with the cables, or the conductors, or the insulators; but an ideal plough had certainly not yet been arrived at. The use of wood for the body of the plough necessitated that it should be protected with some kind of insulating material; the method which had been adopted, from the experience of others, was to dip the ploughs in a composition which coated them $\frac{1}{16}$ to $\frac{1}{8}$ inch thick all over, and was supposed to have the effect of keeping out damp. But in practice that was by no means perfect. On a dry day ploughs seldom gave trouble, but on wet days the troubles were considerable. If he were to state how many ploughs had failed on that day and the previous day, he would hardly be credited. Two ploughs had to be provided for each car: one was working on the car while the other was in the shed, being got ready for work; and in wet weather the ploughs had to be changed every day, and sometimes they ought to be changed every $\frac{1}{2}$ hour to keep them right. The plough exhibited was a good example of the state into which they got in a couple of hours. After 2 hours' running on a wet day the average plough was just as though it had been dipped into a bucket of mud; and electrical engineers would appreciate the difficulty of trying to maintain efficient insulation with 550 volts between two conductors only a few inches apart, practically running through liquid mud. The mud did not appear to come from the conduit itself, which was kept fairly clean. It seemed to be thrown up by the car-wheels in some way, and to get through the slot on to the plough. Figs. 33, Plate 3, showed the connection made between the conductors in the body of the plough and the plough-shoe, by a small flexible fuse. That fuse had originally had a plug contact at each end, and the connection had been made by pushing the plug into a socket. The fuses had given a great deal of trouble. Either the vibration or a little local heating of the plough made the contact loose, and the plug would fall out, and so break the connection. Sometimes the plug made such a bad connection that there was more heating on account of the bad contact than through the current passing through the fuse itself. On later types of ploughs the plug connection had been done away with entirely, and the fuse-wire had been placed under the head of a set-screw; since

Mr. Rider.

Mr. Rider. then there had been practically no trouble at all with the melting of the fuse, except by reason of a short circuit on the plough. It was necessary to find a plough which would not need to be dried every day and to be dipped in a compound. Experiments were being made with ploughs, and he hoped before long to obtain a better type; still, the existing type would work well under better climatic conditions than obtained in this country. One trouble with the insulating compound was that it was inflammable. If a bad short circuit occurred on the plough, or the fuse went, the plough might be set on fire: and it was a serious matter to have a plough alight under a wooden car. He quite agreed with the Author's remarks on the difficulty caused by the provisions of the Tramways Act, which gave local authorities power to prohibit work being carried on over more than 100 yards at a time. It was a serious difficulty; and it was practically impossible to carry out the work in its proper sections, unless the local authorities would forgo their powers in that respect. He was glad to say that, in the majority of cases, permission had been obtained for more than 100 yards to be done at one time; nevertheless, it was a bad thing to have the provision in the Act, because it gave to a borough authority, which might be a little antagonistic, power to place great difficulties in the way of conduit construction. With regard to the three 30-inch water-mains which lay under the track practically the whole way from Clapham to Tooting, he, personally, wished the engineers had seen their way to have the pipes moved. The cost of doing so would undoubtedly have been heavy; but it would have been justified, because, if one of those pipes burst, the whole road was bound to be stopped. There was no doubt that the conduit system was excellent engineering work if it could be afforded—afforded not only in the first cost, but also in the maintenance. In London the expense of cleaning the conduit was heavy, and the expense of maintaining the ploughs heavier still. The latter item it was hoped to reduce, but he did not see how the former was to be lessened so long as the borough authorities, with their mechanical sweepers and men sweepers, swept all their mud into the conduit. With regard to the Appendix, the cost of conduit construction, if cars and power-houses were included, must depend entirely upon how many cars were run. The cost of the road-work was the same whether five cars or ten cars were run per mile, but the cost of the cars and of the power-station was doubled with ten cars; so that it was not fair to take the cost of conduit construction and compare it with another town, unless the cars

and the power-station were of the same size. The electrical details of the line, namely, the generating-station, the sub-stations, the switchboards, etc., which the Author did not deal with, Mr. Rider hoped to describe in a Paper of his own. At the end of the Paper the Author mentioned the names of a number of gentlemen who had been connected with the work, and while what was stated there was quite true, it was not the whole truth. The Author admitted that the ploughs themselves were made essentially to Mr. Connett's design; but if Mr. Connett had not designed more than the plough it would have been a bad thing for the London County Council. He would ask the Author to state in his reply what else Mr. Connett had designed besides the plough. Mr. Rider.

Dr. ALEX. B. W. KENNEDY, Vice-President, remarked that it was of course known that the conduit system was much more expensive than the overhead, but he could not quite agree with Mr. Fitzmaurice that the difference in cost amounted to £7,000 per mile. The system under discussion had cost about £13,500 per mile. It was the first example of the system carried out in London; it had all the difficulties inseparable from the starting of a new system; and it had had to be carried out through some of the most difficult parts of the whole of London. Though it had not had to cross over bridges, where special expense was caused by the necessity of altering the shape of the conduit—as he thought had been the case in later work—it had had to get through the "Elephant and Castle" and St. George's Circus; and therefore he thought it might fairly be expected that further construction of the same type should not cost more. In a country town it was quite possible to construct an overhead line for less than £7,000 per mile, although sometimes the cost was more and sometimes less. He doubted very much whether in London, with the conditions under which the County Council had to work—and particularly under the very onerous conditions which were constantly imposed upon its contractors and engineers by the engineers of the boroughs through which the lines passed, which really made the work extremely expensive—an overhead line would be constructed for much less than £9,000 per mile. He spoke in this matter from his somewhat sad experience of the past 2 or 3 years in finding out how much the County Council had been expected to do which he did not think it ought to have been called upon to do. If he was right, the difference between overhead and conduit was less than £5,000 per mile; and he thought that this figure more nearly expressed the real difference between the one system and the other, as carried out in London itself. Mr. Rider had put the matter Dr. Kennedy.

Dr. Kennedy. rightly in saying that the conduit system could be adopted only in places where it would pay to use it. Dr. Kennedy considered that London was such a place, and he believed that the advantages possessed by the conduit system, at all events in the central districts, where the traffic was densest, were so great, that it would be repeated, as the County Council had repeated it. Of course the difficulties connected with cleaning the conduit, and with other things, especially the ploughs, were very troublesome to begin with; but he would not be at all surprised if, by the time Mr. Rider wrote the Paper he had referred to, he would have found that a great many of them had disappeared, as the result of further experiment, of greater experience, and of improvements in methods of maintenance. He was sorry Mr. Fitzmaurice had not mentioned the alterations which he had made in the further line designed by him and recently opened. He gathered from Mr. Rider's remarks that Mr. Fitzmaurice's principal alterations had been in the sump-pits, and matters connected with the grading of the conduit, in which it was quite understandable that experience would show alterations to be desirable. With regard to rail-joints, he had no special reason for advocating the "Dicker" joint, but it had been very satisfactory in many places, and so far it had been perfectly successful in the present work. The joint actually used was not that which Mr. Rider had described, but was as shown in Fig. 17, Plate 2, the raised fishplate having a bearing all along under the head of the rail. If the two top surfaces actually touched, the joint was wrong, and not right as suggested by Mr. Rider, because there ought to be a clearance there. He did not say that joint was better than all others, but he believed it to be satisfactory. The curious shape sketched by Mr. Rider did not apply to the joint actually made, which was fished under the rail on both sides; in fact it had nothing whatever to do with the London tramways. As to the matter which Mr. Rider had mentioned last, he would be extremely sorry to have it thought that the Paper was wanting, or that he himself, or anybody connected with the work, had been wanting in consideration for his friend, Mr. Connett, whose knowledge of conduit construction was probably as extensive as that of all the [illegible] in the room put together. As engineer to Messrs. J. G. [illegible] Company, Mr. Connett had helped immensely in the work; [illegible] had been most helpful from the beginning, and questions [illegible] had been discussed with him. It was especially stated [illegible] per that the ploughs were to Mr. Connett's design,

because they were practically so, and excellent ploughs they were.[1] But in other matters, since Mr. Connett's firm took up the work, there had been a continual interchange of suggestions on both sides. As he had schemed out the conduit long before the contract was let, and as the work had been carried out substantially to the original scheme, he did not think he ought to go farther than to acknowledge the continuous and very careful help that Mr. Connett had given, and acknowledge also that a great many modifications had been made in discussion with him. He did not like introducing personal matters into the Institution, but as the subject had been raised, he felt bound to say this much. He would like to mention one other point, in connection with the yokes. It might be remembered that on first submitting to the County Council the scheme which they had submitted to the Board of Trade, he had been condemned right and left for not carrying the yokes under the track-rails. In his judgment he had had good reasons for not doing so, and he had been greatly encouraged, after the opinions expressed as to the folly of not carrying the yokes under the rails, by reading a Paper by Mr. Connett, in which the opinion was expressed that the yokes should be central, and fixed more or less in the manner that had been adopted. Dr. Kennedy's idea, however, had been that the yokes would be erected by standing them on concrete at the bottom, and he had therefore designed them with a flat instead of a rounded bottom. When talking the matter over, Mr. Connett had said he would prefer to erect the yokes by slinging them; and by making them of rounded section a certain amount of material could be saved. He had adopted Mr. Connett's views on the matter in order to suit his proposed method of erection; the yoke had consequently been altered in shape, and the method of setting had proved an entire success. Whether or not they might have been erected in another way, he did not know; but the method by which Mr. Connett had erected them had enabled their shape to be improved and their weight to be reduced. He gathered that the actual Dr. Kennedy.

[1] It is much to be regretted that Mr. Rider spoke as if the ploughs which had caused so much trouble were those designed for the Tooting lines, and described in the Paper. This is not the case. The ploughs which had failed were, in nearly all cases, made to an altered design which has proved itself thoroughly defective, and were not the ploughs designed by Mr. Connett and adopted by the Engineer. In regard to the Tooting ploughs very little trouble has occurred, and when a proper system of maintenance is adopted, they will give as little trouble as similar ploughs have for years given in Paris, where they are properly looked after.—A.B.W.K.

Dr. Kennedy. concrete work under ground, the conductors, and the insulators connected with them, had given very little trouble in construction, although they were so largely tentative. Of course, no conduit would drain itself in storm-bursts; and it was apparent that, under certain circumstances, more facilities for drainage were wanted. He understood that Mr. Fitzmaurice had been giving them in his extensions. He hoped that if the conduit system was carried out, as he believed it would be in large cities, the results of further experience might be to cheapen the work considerably. He was not sure whether such a result could be hoped for; but in most work reduction of cost was a natural outcome of further experience. Whether finality had been reached in the various features of the conduit construction, he did not know; but he hoped that further experience might show where errors had been made; they had been mainly on the safe side.

Mr. Connett. Mr. A. N. CONNETT thought that as a description of the work that had been carried out the Paper said the last word. He was sorry the Author had not made some suggestions for new work, which would have been of great value; perhaps he would do so in his reply to the discussion. Mr. Fitzmaurice had referred to a disadvantage of the conduit arising from the difficulty of changing its position. It certainly was difficult to move a conduit when it was once in place; but if it could be foreseen that a conduit might have to be shifted, it was possible to do it with a minimum of expense by putting in the conduit in a temporary manner at first. If extended yokes were used, so that the whole of the structure was bound together, and if the tube was formed with sheet steel instead of concrete; then, by excavating the earth on one side, the whole structure could afterwards be moved with jacks, without interrupting the running of the cars, and at no [v]ery heavy expense. The difficulties of the conduit in regard to [fu]ture junctions, to which Mr. Fitzmaurice had also alluded, [mi]ght be largely overcome by putting in the conduits themselves, [bloc]king the unused tubes with steel plates, and running the [circ]ular rails through; afterwards the paving could be taken up, [and] the points could be put on to the yokes already put in place, [with]out any great expense. There was one slight criticism which [he] desired to make on the Tooting line, in fact on all the lines built by the London County Council, and that concerned [the] point mechanism, which was one of the great sources of [tro]uble in a conduit road. The point mechanism should be [re]duced [to its s]implest proportions, and the use of double tongue-[t]rac[k was] a mistake. It added one-third to the mechanism,

Mr. Connett.

and, roughly speaking, one-third to the chances of danger. He would always use a tongue-point and an open point, and thereby cut out all the mechanism moving the second track-point. This had been done in a number of instances with great success. Another thing was the division electrically of a conduit road into ½-mile sections. He really could not see the use of that; it added very much to the cost, and the reasons for it which might exist in an overhead line certainly did not exist in a conduit line. The 1-mile section used in other great cities, such as New York, would work very well for conduit tramways in London. The breaks in the conductor-bars at slot-points were certainly troublesome. Lately he had had to reduce the length of those points in the Bournemouth conduit, where there was a gradient of 1 in 20, and it was rather a difficult matter for the cars to negotiate a 12-foot break on that gradient. Special insulators had been put in and the break had been reduced to 8 feet. That could be done in the London work if necessary, and it would do away largely with the difficulties referred to by Mr. Rider.[1]

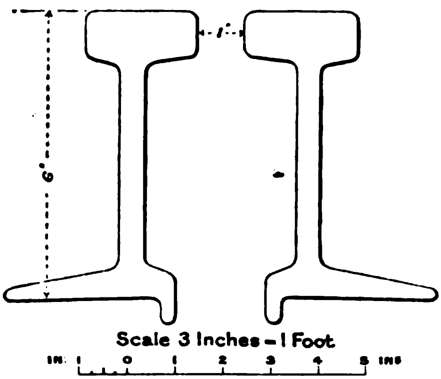
Mr. Trotter.

Mr. A. P. Trotter would have liked to hear Mr. Connett say a little more about the side-slot system which had been so ably developed under him in Paris and at Bournemouth. After visiting every tramway in the United Kingdom, many of them half a dozen times, and after examining several of the tramways on the Continent, he could not help being impressed by some of the permanent-way work, although he had no responsibility with regard to it. The tramway in Budapest was a very old example of a side-slot conduit, and it was a libel on that beautiful city to say that it was a cause of any trouble. He thought the whole of the tramways in Vienna had been re-constructed with side-slot conduits. In Paris there was a large system designed by Mr. Connett with the side slot, and nearer home there was one to be seen at Bournemouth. Reasons for not adopting the system in South London were given in the Paper, but he did not think the last word had been said upon the question. Taking the width of the two running-rails as 4 inches and the slot-rail at an additional 4 inches,

[1] With reference to Mr. Rider's remarks upon the difficulties experienced with ploughs, it appears to Mr. Connett that, these troubles having occurred only a few days before this discussion, Mr. Rider may not have had an opportunity to investigate fully the causes of the failures he mentioned. If he had had, his recital of the imperfect working of the ploughs would, in Mr. Connett's opinion, have been differently expressed. The great difficulties described by him are believed to have arisen almost wholly with ploughs vitally different in design and construction from those described in the Paper.—Sec. Inst. C.E.

Mr. Trotter. there was in the surface of the road nearly 200 square yards to the mile, and in 18 miles nearly 1 acre of polished iron, which need not be there as far as he could see. It was a serious inconvenience to almost every other kind of traffic than the tram itself. The width of the groove was $1\frac{3}{16}$ inch, and it need be no larger with a $\frac{3}{4}$-inch slot at the bottom. The only difficulty he saw was that the slot would then be tapered, and that might be objectionable. It was said that with a side slot the mud was flung into the conduit by the wheel. Experience would show whether that mud could be kept off the plough, and also whether it really made much difference if it were not, because there was evidently a great deal of mud to be found already in the conduit. A $1\frac{3}{16}$-inch groove certainly did harm in catching small wheels, but that would not be intensified at all by the existence of a slot at the bottom. The two evils apparently had nothing to do with each other; and, on the other hand, the side-slot got rid of half the iron in the street-surface. At Bournemouth the slot was 1 inch, and he had not heard of any troubles there. The Bournemouth slot-rail consisted of two similar rails having a drip-piece on the lower flange (*Fig. 37*). If more conduit lines were to be built, and of course they would be only for gilt-edged tramways, he hoped the question of the side slot would be reconsidered. Although it appeared to involve complications at points, that difficulty might be overcome more simply than by the very ingenious method used in Paris and at Bournemouth.

Fig. 37.



Mr. Campbell. Mr. A. H. Campbell thought that if there were more co-operation between the tramway authority and the road authority, whereby a pavement could be laid that would be less mud-producing than most of the pavement of South London, and a better organized system of scavenging, a great deal of the mud that went into the conduit need not be produced. On the Tooting lines, the track was chiefly paved with granite sets, which were not very bad in regard to production and retention of mud. But at the sides of the

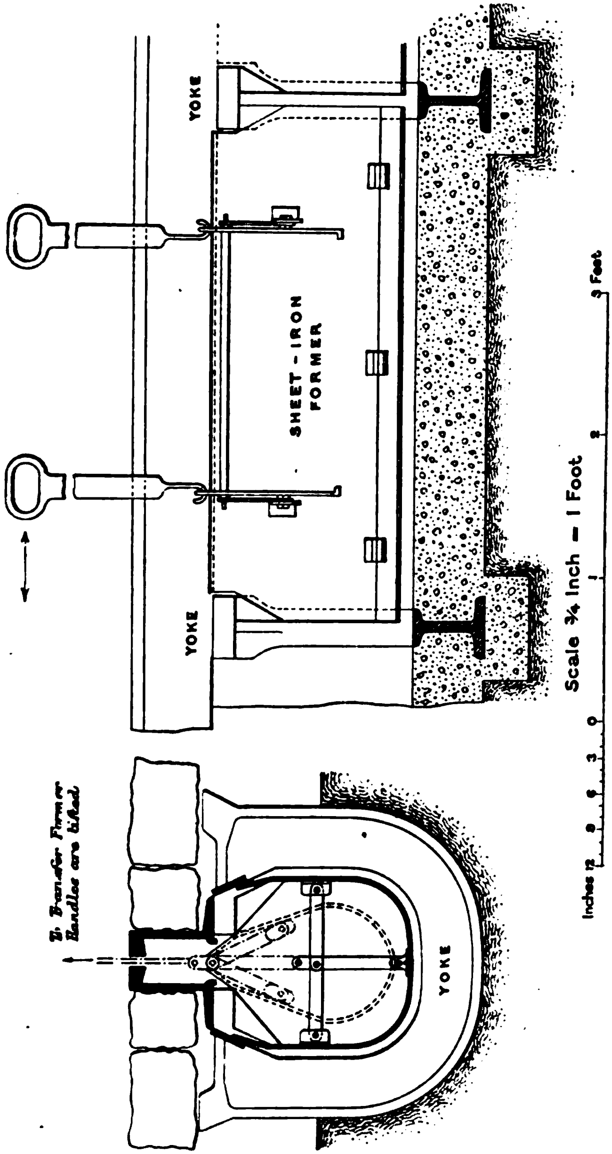
track there were, in places, considerable lengths of ordinary macadam, from which, in climates like that of London, a great deal of mud was quickly produced by the traffic. That mud was thrown on to the tramway-track, and the slot was a handy outlet for its removal from the surface. If some of the rock asphalts could be adopted, not only for paving the tramway-track itself, but for the whole road, from curb to curb the surface would be, certainly sanitary and cleanly, and probably less mud-producing, than any other. In Glasgow he had noticed some time ago long lengths of asphalt tramway-track being laid without any protection of the edge of the asphalt adjacent to the rail. That was a defect, because undoubtedly a great deal of wear occurred at the line of contact between the pavement and the rail itself, which could be prevented to a large extent by the insertion of chequered steel blocks, alternating with the asphalt surface, at about 4 to 5 inches apart. Asphalt had another advantage. It could be laid $1\frac{1}{2}$ inch to 2 inches thick, whereas the depth of sets or wood blocks must be at least 5 to 6 inches. The thinner layer of asphalt was much easier to renew when worn, and was certainly quite as durable as the best form of wood paving. Its shallower depth allowed the track-rail to be more firmly embedded in the concrete, which did much to minimize the wear of the rail, especially at its weakest point, namely, the joint. It was well known how rapidly rail-joints wore out, unless extreme care was taken to support the joint properly. In the tramways with which he had been connected, no other plan of holding the rail-joints than the usual 27-inch fishplate was now in use. The sleeve which the Author described was not cut out of the tread of the rail, but an ordinary fishplate was used, leaving the tread of the rail unaffected; and from 3 years' daily observation, with cars passing in a 3- to 5-minute service, working 18 hours every day of the week, no subsidence had been observed, nor was any apprehended. With regard to cost, he had constructed permanent way for overhead work with a standard gauge of 4 feet $8\frac{1}{2}$ inches, in the vicinity of London, for about £5,200 per mile. If to that was added about £1,250 for overhead work, the total was £6,450 per mile, as compared with £13,895 given by the Author for this conduit system. He agreed with Dr. Kennedy, however, that the figures given in the Appendix were not necessarily to be taken as the cost of future installations of the conduit system. Mr. Rider, fresh from Plymouth, evidently did not take very kindly to the more complex conditions of the conduit system, as compared with the facile overhead system; but no doubt with more experience, the defec- Mr. Campbell.

Mr. Campbell. inevitable in any new system, would be overcome. In case any borough authority should be tempted to run away with the idea that, because the conduit had been adopted for what was perhaps the finest tramway system in the kingdom, it was therefore the best, he might point out that he had found recently, from examination of the profit and loss accounts of electric tramways, that out of about eighty municipally owned and worked tramways, only three could survive bankruptcy if they had to bear the cost of the conduit system. That would show the need for caution in repeating the conduit system anywhere but in London, where the conditions of traffic, and the extraordinary revenue which might accrue from the vast number of passengers, could make it pay. He thought the advice given by Dr. Kennedy, that only in the great central zone of London should the conduit system be applied, was sound; and if it were followed, the County Council tramways would yield a profit, and be a splendid accommodation for London. But if, through the action of borough councils, the conduit system were extended into the more outlying parts of the metropolis, he could not see how even the tramways of the County Council were to be anything but a financial failure.

Mr. Scott. Mr. E. Kilburn Scott stated that a joint similar to the Dicker joint had been used for some years in Berlin, and had proved an entire failure. The wheel burred over the edges of the rail and the fishplate in opposite directions, as described by Mr. Rider, so that in time the fishplate was forced outward. The burrs could not easily be chipped out. One point which he thought should be put on record, with regard to the recent construction of the tramways, was the method of forming the concrete sides of the conduit which had been introduced by Mr. J. E. Hall for Messrs. Wm. Griffiths and Co. The original method of forming the concrete was by means of several pieces of sheet-iron, which, with their wedges, needed a good deal of manipulation, and when required to be moved had to be fished for through the slot. In the Hall former or centering there were two hinged plates connected together by two pairs of toggles as shown in *Figs. 38*. When pushed down the toggle-levers held the plates firmly in position and the concrete was then rammed outside them. When the concrete had set, the former was not taken out of the conduit, but was simply slid along to its new position; there was no fishing for pieces through the slot, as he had seen such in Paris several years ago. He thought Mr. Rider's last remark was justified. It had been his duty to represent the *Electrician* when the London County Council conduit was first shown at the Camberwell depôt, and he had felt it his duty to

criticise it severely. No one had greater admiration for Dr. Kennedy Mr. Scott.

Figs. 38.



than he had, but he thought it was a good thing that Mr. Connett had taken a part in the design of the conduit as actually laid down.

Mr. Scott. Among other faulty features of the original design had been the fact that the rail was supported from the bottom instead of being suspended. If the supports from the bottom had remained in, he was afraid the conduit would never have worked.

Mr. Thomson. Mr. T. FRAME THOMSON failed to see that any valid technical reasons had been put forward for the substitution of the conduit system for the overhead. The Chairman of the Highways Committee of the London County Council had given what appeared to be the real reason in the case of the Tooting lines, namely, that there still existed a strong prejudice in England against overhead wires; but so far as Mr. Thomson's observations went he had not found such an objection in other countries. In Berlin and other places where the overhead system was largely used and where people had a keen æsthetic sense, it was not regarded with the animosity with which it appeared to be regarded by the County Council. As to the difference in cost, it certainly seemed that something more than mere attractiveness, especially in such a district as South London, was required to justify an extra expenditure which he thought was correctly stated, with all deference to Dr. Kennedy's opinion, at £7,000 per mile. He had arrived at that figure in his own mind before hearing Mr. Fitzmaurice's remarks, and it had been confirmed by other speakers. One matter which he had hoped to hear elaborated was the subject of rail-joints, which was one of the most important of all the subjects connected with electric tramways at the present time, requiring some more satisfactory settlement than it had yet received—or at all events a more widespread knowledge of its satisfactory settlement, if such a thing had been arrived at. He had seen very satisfactory results obtained with a 9-inch rail, that depth giving sufficient distance between the head and the base for the bolts to be staggered; and he knew of rails laid with that joint which were giving no trouble whatever. With the 6-inch rail the depth was not sufficient; and even with a fishplate having six bolts, a great deal of trouble seemed to have been experienced. During the last 6 months he had seen various municipal tramways in England where the lines had been laid 3 to 6 years, with a 6-inch or 7-inch rail, and with ordinary fishplates with six bolts; and in every case great difficulty had been experienced with the joint. It was not merely a matter of having to look after joints, and the annoyance caused by running over them: it was the serious expense that had to be faced in reconstructing the track within half the normal life of the rails. If the joints gave out in 3 or 4 years, the road had to be relaid to a

large extent. He did not understand how any joint that had less than six fishbolts could be regarded as even plausibly satisfactory. Even six were not altogether satisfactory, judging from cases he had seen where that number was a distinct failure. Undoubtedly from a practical financial point of view that was the greatest bugbear that had to be faced at present in the introduction of electric traction. In one place he had seen a new road being made with what were called "anchor" joints, an inverted section of the rail being riveted up through the flange of the track-rail. So far as stiffness alone was concerned, that was as nearly perfect a joint as could be got. But it remained to be seen what would be the effect of having the anchor buried in the concrete, so that the joints rested on metal while the rest of the rail more or less retained its flexibility on the concrete. However well the concrete was laid, and however true the track might be, there was bound to be a certain amount of movement in the rail due to the passage of heavy cars. Instead of being an improvement to the track, the anchor might easily become a serious difficulty, owing to a continual repetition of small shocks, which would gradually disintegrate the concrete, and throw the joints into a worse condition than before. Another interesting joint, which was being carefully studied in England, and applied on a large system, was the thermit-welded joint; and he hoped someone with experience of that method would give some definite information about it. There was no point connected with electric traction on which engineers seemed so entirely at sea as the rail-joint. It might be that, electric traction having started, as it were, from the wrong end—from the electrical end instead of from the railway end—electrical engineers were only now learning what the connections of the rails should be. Many engineers who were laying out electric lines were experimenting with things that engineers brought up on steam-railways had been taught to regard as heresies. Mr. Thomson.

Sir ALEXANDER R. BINNIE, Vice-President, remarked that the observations of the last speaker carried him back a few years to the time when the question of the mode in which electric traction should be introduced into the London tramways was under discussion. At that period he had somewhat to do with the decision at which the County Council arrived; and he could assure the members that it was not on æsthetic grounds at all that the decision had been arrived at. It had been clearly seen at once, that, whether the difference was £4,000, £5,000 or £6,000 per mile, the conduit system was inevitably the more expensive Sir A. Binnie.

Sir A. Binnie. system of the two. But other matters had to be taken into consideration, one being that, if an overhead system was introduced, it was not practicable to restrict it to particular parts. An interesting diagram had been prepared by Dr. Kennedy, showing what would result in the neighbourhood of, for instance, the "Elephant and Castle," to say nothing of Charing Cross, or the junction of the Strand with Waterloo Bridge, or of Holborn with Gray's Inn Road. Not only would there be overhead wires, but there must also be some support for those wires; and then had arisen the question how far would the local authorities allow those obstructions in the streets. It had soon been found that the cost of either system was going to be greatly augmented by the demands of the local authorities, who regarded, and probably rightly regarded, the streets as their property. Those subjects had weighed very considerably with the County Council in coming to the conclusion at which they arrived. There was also another point, which might possibly be remote, but which he believed was not quite so remote as some thought. As long as the overhead system was new, it was undoubtedly a good and workable system; but the time would arrive, say 15 to 20 years hence, when that overhead system would not be so new as it was now. Even in its juvenile days accidents had occurred from the fall of wires; and the liability to accident would undoubtedly increase as the material of which the overhead system was constructed grew older. On comparatively rural roads, or in remote districts, those accidents were chances which the engineer could perhaps afford to take. But in the thickly-populated districts of the largest city in the world they were things which had to be avoided, as many other things had to be avoided, by the public authority incurring additional expense, in order to preserve, as far as possible, the safety of the people for whom it administered the city.

The Author. The AUTHOR, in reply, remarked that several speakers had referred to the initial cost of installing the conduit system. While there could be no doubt that the conduit was more expensive than the overhead system, it must not be lost sight of that in many branches of the work the cost was precisely the same for both systems; the difference in cost occurred largely in the permanent-way equipment, and, to a small extent, in the feeder and sub-station switchboard arrangements and in the collecting-apparatus. The figure given by Mr. Fitzmaurice for New York was high not only on account of high wages but because

The Author.

unnecessarily heavy yokes had been employed. These yokes were 3 feet in depth and extended the full width of the track. With such a superfluity of metal, entailing a large amount of concrete to hold it in place, it was to be expected that the cost would be considerable. The figure of £7,000, given by Mr. Fitzmaurice as representing the difference in cost between the two systems, had been obtained, he understood, by comparing the actual cost of conduit construction in London with the actual cost of overhead construction in other large towns throughout the country, modified to suit the scale of wages and materials prevalent in London. He agreed with that principle, but thought that there were unusual conditions in London which should be taken into account also. The borough councils were the street authorities, and their onerous requirements as to paving and grading had to be fulfilled. The whole of the road-breasts along the route were laid with wood paving, and in laying the new margins considerable expense was entailed in bonding the new material with the old, due to alterations in level or to the worn condition of the old wood paving. The cost of marginal paving-work ran to over £1,200 per mile of single track, and this would have been practically the same for the ordinary track of the overhead system. Another expensive feature in the lines described was the special work. This represented one-eighth of the road-work expenditure—an unusually high proportion for such work. This outlay, with the exception of the cost of the slot-work, would have been necessary in an overhead scheme, with the addition of the trolley-wire special work. With regard to the purely conduit costs that were not applicable to the overhead system, the provision for draining the lines had been rather costly. The average depth of sewer was 20 feet, and there were not many towns in which it would be necessary to go down so deep in order to get sewer-connections. The cost of this work had amounted to over £500 per mile. Again, there were the pipe and other obstructions encountered in carrying out the work. To remove the three large water-mains which ran under the track for about 2 miles, as advocated by Mr. Rider, would have cost more than all other diversions put together. Such an expenditure had not been considered justifiable, when it was possible to avoid it by raising the road here and there, even though the drainage-pits in places had to be made a little shallower in order to avoid moving the pipes. The cost of dealing with obstructions worked out at £458 per mile of single track. It would be seen from the figures in the Appendix that the cost

The Author. of similar work in Edinburgh was £478, and as the Water Company there removed all pipes entirely from underneath the tracks, and to a large extent duplicated their system, paying one-third of the cost themselves in lieu of getting new pipes, it would be seen that the engineers had dealt in a liberal way with pipe-diversions in London, in order that the working of the system should not be unduly hampered. Taking all these circumstances into consideration, the difference in capital expenditure between the two systems should, under average conditions, be considerably less than £7,000. He was at a loss to understand, even with that high figure, how Mr. Campbell could have arrived at the conclusion that only three towns in this country could afford conduit construction. It had been installed in numerous towns on the Continent and elsewhere with good results; and the prosperous condition of tramways in a large number of English towns, as evidenced by the large sums applied annually by Tramway Committees to the relief of the rates, would lead to the belief that the extra capital charges entailed by the conduit could easily be met, where that form of construction was applied with due regard to the principles laid down at the beginning of the Paper. It should be borne in mind, also, that in other towns where the rates were not thus relieved the authorities did not wish to make a profit out of the tramways, but sought rather to run them at the lowest fare that would cover working-expenses, with the object of accomplishing the end for which tramways were created, namely, to provide a cheap and convenient means of transit. As to the inconvenience attending reconstruction, he need only say that it was undoubtedly best to lay long strips of temporary line alongside the track, and to have as few loop-lines as possible, as the latter were a nuisance to the ordinary street traffic. With regard to the flexibility of the conduit system, where a branch line was not likely to be required for many years it was better to form the permanent foundations only for both tracks. In these cases, in order to insure ultimate proper fitting, it was advisable to link all the rail-castings together at the time the concrete foundations were laid. They could then be dismantled and the straight rails laid through. Nowadays, however, points and crossings were being introduced of such hard material that some tramway-managers were asking—"Do you find your steel tires wearing more rapidly on account of the hardness of the special work?" In the £900 which Mr. Fitzmaurice suggested might be lost, he had included all the foundation-work, which did not come into the account at all. The surface-work would not amount to

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more than £500, and only a portion of that could be lost. With regard to noiseless forms of paving, it was possible to use wood for conduit work, with ¾-inch slots, but it entailed a great deal of trouble in selecting and laying the wood. As to rock asphalt, a number of experiments had been carried out from time to time, but, as Mr. Fitzmaurice had said, satisfactory paving of that description had not yet been arrived at. The use of chequered iron blocks in conjunction with asphalt, suggested by Mr. Campbell, would defeat the object aimed at, which was to lay down a noiseless paving. The difficulty of providing paving-plates underneath the slot-rail flange could be overcome at insulator-pits by employing a short plate on either side of the pit and supporting the pit end in a stirrup bolted to the slot-rail. With a good collapsible centering, such as that shown in *Fig. 38* (p. 199), the paving plates were hardly necessary at all, as the concrete could be trusted to maintain its form without additional support of any kind. Shallow conduits were undesirable, but sometimes they were rather welcome for financial reasons. Regarding the track-rail joint used, he had seen it laid upon about 100 miles of line and had formed a good opinion of it. He thought the chief difficulty with joints was that, whether rails were supported from the fishing-surface or from underneath, the rail-heads might not be level. In that condition, with a car travelling on to a lower rail, pounding would ensue; and the more rigid the track, the worse that effect would be. The raised fishplate in the Dicker joint in a large measure prevented this hammering action by splitting the joint, thus securing a continuous running surface for the wheels to travel over. He was inclined to agree with the views expressed by Mr. Thomson about the beneficial effect the use of deeper rails would have on the life of the permanent way of tramways, especially on lines where there was a frequent service of heavy cars running at high speed. He thought, however, that Mr. Thomson placed too high a value on the benefits derived by increasing the number of bolts at a joint, as bolts which were more than 12 inches away from the rail-end played quite a secondary part in ensuring a good joint. Mr. Connett had advocated one track-tongue at junctions instead of two, as used in the South London line, on the ground of simplicity of construction. Apart from the longer life the latter form of construction had, the Author considered that the slight trouble of looking after an additional tongue and mechanism was more than compensated for by the comfort afforded by the cars riding on a bearing surface all the way. He had no serious objection to side-slot construction, but there were reasons against it, one being that it offered a readier access for surface-water and mud. Another objection was the width of the groove, although he could not say

The Author. that he had heard of any serious accidents arising from this. With regard to the extent of surface metal with the two systems, Mr. Trotter had not made it quite clear that with the side-slot system there was also an addition to the surface metal, due to the slot-rail forming the guard to the wheel being $2\frac{3}{8}$ inches wide instead of the $\frac{1}{2}$ inch or $\frac{5}{8}$ inch usual in an ordinary track-rail, *Fig. 37* (p. 196.) The additional metal in the streets represented 196 square yards per mile of single track with the centre slot, and 43 square yards with the side-slot or, 1 acre in 25 miles with the former, and 1 acre in 110 miles with the latter. The suggestion made by Mr. Connett about increasing the length of the electrical sections was deserving of attention, and the Author thought that sections might with advantage be increased to 1 mile at least, except where the car-traffic was very heavy, in which case it might be necessary to reduce the length of the section in order to avoid too great a drop in the line-voltage. Plough-hatches, however, might be retained at every $\frac{1}{2}$ mile, as had been done in South London. These hatches, although seldom used, would in an emergency afford a convenient means for inspecting and handling ploughs. Regarding the size of insulator-pits, where distributing-cables were connected to the conductor-bars, the Author agreed with Mr. Rider that it would be an advantage to make them slightly larger, in order to give more room for connecting the cable, as was done in pits at breaks in the conductor-bars at special work. The mechanical breaks in the conductor-bars, although somewhat numerous at some parts of the line, appeared to cause very little discomfort to the passengers, or delay to the car-traffic. This was explained by the fact that the engineers had voluntarily increased the length of break at track-crossings by dispensing with the short bars shown in *Figs. 31*. With regard to the criticisms passed on the design of the ploughs, the type shown in Fig. 33 was practically the same as had been installed, and worked with such excellent results, in Paris,[1] New York, Brussels, Lyons, Bournemouth and other places. The more successful results obtained in Paris could not be attributed to a less gathering of mud on the ploughs and in the conduit, for, assuming

[1] In Paris, where there are on an average eighty cars running on the conduit lines during working-hours, a breakdown in the insulation of the ploughs is exceedin[illegible] During the period of serious plough trouble in London, from Dece[illegible] February, 1904, the Paris lines were operated without a sin[illegible] of a plough burning up or developing a serious earth, a[illegible] ths in question were exceptionally wet. On a recent visit [illegible] Author was informed by the Car-Shed Superintendent [illegible] not more than one failure occurs in 6 months.—A. M.

the Paris streets were kept slightly cleaner than those of South London, this was more than counterbalanced by the greater facilities which were offered for mud to enter into the side conduits of the former, than into the centre conduit of the latter. This was partly due to the splashing action set up by the car-wheels, which ran on the slot-rails of the side conduit, and partly because the slot-rails of the side conduit did not form the highest point in the roadway, as they did with the centre conduit. The opinion expressed by Mr. Rider that sometimes, during wet weather, ploughs should be changed every ½ hour if the lines were to be worked successfully, did not appear to be shared by the Paris tramway authorities, as plough and car finished their day's outing of 16 hours' duration together, and during that time the ploughs were not inspected or attended to in any way. The Author could not help feeling that Mr. Rider had been rather precipitate in this matter, and ventured to think that if he had investigated more thoroughly the plough-failures which had occurred recently he would have modified considerably his criticism, so far at least as the type of plough described in the Paper was concerned; but, as regarded a modified type of plough which had been employed, the Author felt, judging by the results attending its use, that Mr. Rider might have been fully justified in his remarks. These modified ploughs had been adopted by the London County Council, on the advice of their officers, for the Greenwich and Peckham lines, and concurrently with the opening of these lines—about the beginning of 1904—serious failures in the ploughs had appeared. It would be seen from Figs. 33 Plate 3, that the original plough-shank consisted of two steel plates, and that, apart from the mountings, the main body of the plough-bottom consists of three wood plates. In the modified plough, the shank consisted of three steel plates, and the bottom was composed of two outside wood plates, two pieces of specially-prepared millboard, and a middle portion formed by extending the middle shank-plate about half-way down, the plate-end being in very close proximity to the uninsulated lead terminal, and piecing round the plate with wood. Consequently a radically new plough had been created, and it was this modified plough which had caused nearly all the trouble. He understood that several hundred ploughs of this kind had been withdrawn from service, to be altered on lines following the original type. The trouble which had occurred in the original ploughs had been a very small proportion of the whole, and much of it might have been avoided had the separate wood plates been dipped before putting them together, and had a well-tried plough-insulating compound, such as that referred to in the The Author

The Author. Paper, been adhered to throughout, instead of experimenting with other compounds; especially as these ploughs had been subjected to a much more severe strain than was considered expedient elsewhere, in that the car- and repairing-sheds had not been so well equipped for treating the ploughs. While he did not suggest that the Tooting plough was incapable of improvement, and thought that efforts in this direction should be devoted chiefly to reducing the number of parts, and to securing a plough which required no dipping, he did maintain that, given systematic treatment, the present plough was a workable article, capable of giving excellent results, as had been abundantly proved during the 10 years it had been in use elsewhere. As to the cost of cleaning, this was given as ranging from £5 10*s.* per annum per mile of single track in Washington, where the streets were well kept and the cleaning-chambers numerous, to slightly over £100 in Paris, where the streets were flat and badly kept, and the cleaning-chambers were at long intervals. Paris might be regarded as abnormally high; because at Bournemouth, with somewhat similar construction, but with undulating, well-kept roads, the cost was estimated at about £20 per annum. The greater cost of working conduit than overhead tramways seemed to vary between 0·2 and 0·55 per car-mile; but this was not a good basis of comparison, as the car-mileage varied so materially.

Correspondence.

Mr. Howard-Smith. Mr. W. HOWARD-SMITH remarked that the capital cost of a tramway was so largely represented by the permanent way, and in particular by the rails, upon which all the money had to be earned, that it was of primary importance that these should be as perfect as possible in every detail of design as well as manufacture, in order that the longest practicable life might be attained. In the design of the track-rail (Figs. 17 and 18, Plate 2), there were somewhat unusual features, and in particular the wide fishing-angle of 30°—15° each at top and bottom—was quite a departure from prevailing methods in British and foreign electric tramway practice: it would appear rather to favour a return to the wide fishing-angles usual in the earlier tramway rail-sections, but which had been discarded soon after the advent of electric traction. For railway-rails it was usual to adopt wide fishing-angles, but the conditions which made this essential did not prevail in

Mr. Howard-Smith.

street-tramways. For instance, on railways it was customary to allow freedom of rail-movement in expansion and contraction. Again, the fishplates were accessible, and the bolts could receive attention whenever required. With tramways on public roads the conditions were quite different, as the fishplates were embedded in the paving, and generally remained untouched for considerable periods; and, as the same amount of provision for expansion and contraction was not necessary, it was usual to adopt somewhat flat fishing-planes, in order that the support afforded by the fishplates might be as direct, and the stress upon the fish-bolts as little, as possible. Fishplates with narrow fishing-angles could be jammed in fairly tightly, and would probably remain so for a long time, a little stretching of the bolt or slacking of the nut not appreciably loosening the joint; whereas with wide angles of contact the fishplates were apt to work loose much more quickly, thereby leading to deterioration in the rigidity of the rail-joint. Even in railway-rails it was not considered desirable to have as wide fishing-angles for flanged, or flat-bottomed, rails as for bull-headed rails, and recently there had been a tendency to make the angles of the latter less than heretofore. For bull-headed railway-rails a combined fishing-angle of about 40° was now generally favoured, while for flanged rails 24° to 28° was usual; the Committee on Standard Rail Sections appointed by the American Society of Civil Engineers recommended not more than 26°. A main reason for this difference was the greater lateral rigidity imparted to flat-bottomed rails by having a flange about 5 inches in width—for, say, a 90-lb. rail—as against an overall width of 2½ inches in a bull-headed rail. The girder tramway-rail, shown in Figs. 17 and 18, had still greater lateral rigidity due to its 7-inch flange and a head about 4 inches wide. If, therefore, 40° was the best angle for a bull-headed rail having a width of 2½ inches, and, say, 28° the best angle for a flat-bottomed rail with 5-inch flange and 2½-inch head, then, for a tramway-rail with 7-inch flange and 4-inch head, the fishing-angle should, following the foregoing considerations, be proportionately less: and this was generally the case in practice, the angle adopted being, as a rule, 17° to 20°. In the British Standard tramway rail-sections, a bottom angle of 7° and a top angle of 12°, giving a total fishing-angle of 19°, had been adopted. As an indication that this latter angle did not at all verge towards an extreme in narrowness, might be cited the fact that for the Burton-on-Trent tramways, recently opened, the rail had a combined fishing-angle of only 12°, namely 6° each top and

Mr. Howard-Smith. bottom. So narrow an angle as this was not, however, to be advocated. With the particular form of rail-joint described in the Paper as having been used in the straight portions of the track, which made it possible for the raised fishplate to receive impact directly from the car-wheels, as also from road-vehicles, it would certainly appear desirable that the foot of such fishplate should rest upon as flat a plane as practicable, rather than bear, almost upon tip-toe as it were, upon a slope having an inclination as steep as 15°. Another peculiarity of this fishplate lay in the departure from the usual rule that the maximum amount of support should be afforded to the rail-head by fishplates having as wide bearing-surfaces as practicable; although at the same time there was little gained by one wing of a fishplate having a greater fishing-surface than the other, and, generally speaking, it was desirable that the bearing-surfaces of both fishplates should be approximately equal. In the rail shown in Fig. 17 the raised fishplate had a top fishing surface only about $\frac{1}{4}$ inch in width to support the underside of the rail-table; and even this width was theoretical; probably the actual bearing would be even less. In practice it was found that this particular part of a fishplate was subjected to the greatest wear from attrition, due to the vertical and vibratory movements of the rail-ends; and such a narrow surface was liable to become quickly worn down, especially as, from its peculiar shape and situation the fishing-shoulder was likely to be continually fed with gritty particles and moisture passing down the $\frac{1}{16}$-inch opening between the rail-table and the raised fishplate. Again, if the rail-table was rolled even the slightest degree deeper, or the fishplate the slighest degree wider between fishing-angles, than was theoretically required; or should the slot in the rail-end not be planed out absolutely clean in the corners, or the fishplate itself be a trifle too long, or not cut absolutely square—not at all impossible contingencies; then the fishplate would not go home tightly to the underside of the rail-head, but would merely touch at a point, thus depriving the head of proper support and increasing the tendency to wear. If, moreover, the height of the fishplate between fishing-angles were increased by only $\frac{1}{64}$ inch, or the fishing-opening of the rail were diminished by a similar amount, the effect would probably be to make the vertical space as much as $\frac{1}{8}$ inch in width, instead of the theoretical $\frac{1}{16}$ inch. The fishing-surface at the bottom of the raised fishplate had a width of $\frac{5}{8}$ inch, while the fishing-width at the top and bottom of the small fishplate was $\frac{1}{2}$ inch in each case: the No. 4 British Standard section had a fishing-surface $1\frac{3}{16}$ inch wide at all four

bearings. Again, the double-taper angle of the top surface of the flange (Fig. 17) was not liked by rail-makers, as the outsides of the flange were so very flat (namely about 4° angle), that it was difficult to squeeze the steel into the rolls in the squabbing pass so as to ensure flanges of full width and perfect shape at the toe. Mr. Howard-Smith.

Mr. W. H. Pretty observed that from the experience of railways it would seem to be essential for continuous and steady running that the rails should be of the nature of continuous girders, and the joints should be of the same order of rigidity and durability as the remainder of the rail, which behaved like an elastic bar under the succession of transverse loads brought upon it as the trains passed. A fairly rigid track would entail a correspondingly rigid joint for smooth running, and no mechanical joint using bolts for fastening was likely to satisfy this condition. It would be interesting to have some exact particulars of the expansion and contraction of welded tracks buried after the manner of street tramways, which might also seriously affect the durability of mechanical joints. The fishplate shown in Fig. 17, Plate 2, where one plate was level with the surface of the rail, was obviously bad, since the rail, which was of considerable mass, was relatively not so free to move as the parasitic plate which, with its attachments, behaved somewhat like an elastic body attached to a rigid mass, and was therefore likely to receive all the hammering effects of the car-wheels. The helical nut was a doubtful servant and might defeat its object, should a workman not grip the helix immediately next the fishplate when tightening up. He was inclined to think, that in the hands of a good platelayer, the solid, tight-fitting nut was to be preferred. In connection with mechanical joints, it might be interesting to note that oxidation between iron and steel plates produced a pressure within the joint, which was sometimes useful and sometimes detrimental. The following Table was suggestive of Mr. Pretty.

—	Specific Gravity.	Relative Volume.	Increase in Volume.
			Per Cent.
Hematite—Oxide of iron (Fe_2O_3)	5·23	1·49	49·0
Göthite—Hydrous oxide of iron ($Fe_2O_3.H_2O$) . .	4·2	1·86	86·0
Limonite—Hydrous oxide of iron ($2\ Fe_2O_3.3\ H_2O$)	3·8	2·05	105·0
The unit of volume being steel of	7·8	1·00	..

Mr. Pretty. possibilities which produced between pl from a bolt or rive a definite pressure co in the course of tim destructive action wa ironwork and occasi when the riveting w tion appeared to dep and would vary in approaching nearer of the steam locomo while the pressure t nut upon its bolt; b defeat any benefit like laid track, and would separate the fishplate years prior to their u chairs appeared to seen very old railwa and quite recently sc horse-tramways at Le of $\frac{1}{8}$ inch; others wh of a similar nature, ha section and quite nea system was a step tow the ideal would be re and the train or car polyphase transmissio satisfied with the prog

The Author. The AUT in re Smith's re n th that the fl med be consid app matter: mig creasing ng-e which e to s howe ntent later s, it v acc he exa ext arther, fla would o ithmet

at $10\frac{1}{2}$ inches. Whatever the basis of working, arithmetical, geometrical, or empirical, a stage must come when the high value attached to stiffness must be set aside, and other factors must be considered. For example, taking variation in section and considering the effect produced (*a*) on joints of the standard British section with combined fishing-angle 19°, and (*b*) on the section given in Fig. 17, with a fishing-angle of 30°, by the $\frac{1}{64}$ inch variation allowed by the standard rail-specification in the total height between the fishing-surface, and dealing with the case where one rail was normal and the other $\frac{1}{64}$ tight in the fishing-surfaces; in case (*a*), when the fishplate was bolted up hard to the tight rail, it would require to be bent inwards about $\frac{1}{16}$ inch before it bore on the fishing-surfaces of the other rail. It was manifestly impossible for the fishbolts to do this exactly opposite the joint, with the strong section of fishplates at present employed; and the result was that, although a good bearing might be secured at the second and third bolts, no bearing was obtained at the rail-end opposite the first bolt, where it was most needed. In case (*b*) the effect was much less, as the fishplates only required to be bent $\frac{1}{32}$ inch in order to gain contact. Other reasons, such as increased life, uniformity of top and bottom fishing-angle, might be brought forward in favour of the London section; but the foregoing illustration might show that there were distinct advantages with the steeper angle, which might outweigh the advantage of greater support given by the standard section. Mr. Howard-Smith had pictured various complications which might produce bad results at joints, but none of the cases connected with the preparation of the joint did occur, for the simple reason that the sleeve was milled out and checked by gauge; and Mr. Howard-Smith's other general remarks about fitting were equally applicable to all joints. Regarding the restricted width of fishing-bearing under the head, with the Dicker joint this was a disadvantage, but the Author had had frequent opportunities of examining rail-joints of different forms, and in the great majority of those inspected he had found that only a limited width of the fishplate actually bore on the rail. For example, in a fishplate with a top 1 inch wide, on an average only $\frac{3}{8}$ inch width would be touching. It was true that the double-angle flange was not so easy to roll as the ordinary flange; but the difficulty was a very small one, and rarely, if ever, was a rail rejected on account of faulty angles. He was disposed to agree with Mr. Pretty that it would be an improvement if the fishplates were The Author.

The Author. more rigidly held. With regard to oxides of iron gathering the crevices of the joint, and attaining sufficient strength force out the fishplates, he was convinced that the vibration a rail-joint would render this impossible.

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19 January, 1904.

Sir WILLIAM H. WHITE, K.C.B., D.Sc., LL.D., F.R.S., Preside in the Chair.

The discussion on Mr. A. Millar's Paper, "The Electri Reconstruction of the South London Tramways on the Cond System," occupied the evening.

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26 January, 1904.

Sir ALEXANDER RICHARDSON BINNIE, Vice-President, in the Chair.

(*Paper No. 3459.*)

"The Sanding-up of Tidal Harbours."

By ALFRED EDWARD CAREY, M. Inst. C.E.

ON a tidal foreshore, when the balance of the littoral forces is disturbed by solid works, especially when moving sand is present, alteration of the contours of depth follows as a natural consequence. The art of checking local denudation by groynes consists in so controlling and directing these forces that a shingle or sand barrier, as uniform and constant as circumstances will permit, is substituted for a protection which travels under the action of wind-waves. It is thus sought to confine the oscillation of the shingle within the area between groynes, and, as far as may be, to retard leakage to leeward of the tract of coast dealt with.

If the wind be dead on-shore, steep slopes of shingle and flats of sand result; whereas, if the wind strike the coast obliquely, the shingle is dragged down to a long slope, the groynes being denuded and gorged on their lee and windward sides respectively. The most perfect system of groynage, as to spacing, height and angle, is that in which such denudation and gorging are reduced to a minimum. The effects of ground-swell and of tides are much alike, their action producing terracing.

The Author's intention is to consider how the littoral forces tending to sanding-up affect harbours, of which there are, broadly, two distinct types, namely, (1) those which shelter an area of sea-front where no river debouches, and (2) similar works at the mouth of a river or estuary, of which the effluent forces may be utilized for the purposes of scour. Sluicing-basins may be provided, or impounded inland waters made use of, in either case.

There has been much theorizing as to the merits of tidal scour. The older reports on the removal of bars may be summed up as almost invariably recommendations to alter the configuration

of the entrance-piers and thus to carry the bar into deeper water, where it offers less impediment to shipping. Minard[1] gives a series of plans of the entrances of various Channel ports at different dates from 1698 onwards. These are of great interest; for in them can be traced the local, and even much of the national, history of France. The earlier plans generally show deep, abrupt entrances, in which the channels were obviously maintained by the efflux of extensive land-waters. As embanking and reclamation proceed, the channels shrink in depth, and the construction of piers is pushed on apace, to reach deeper water. At Dunkirk, for instance, this progressive extension went on for 250 years. The authorities of the day hoped, by projecting the piers into deeper and deeper water, to get beyond the limit of depth at which shoaling would result; but, as fast as the piers were extended, the sand travelled seaward, and a bar mocked their efforts as before.

Santa Ana Harbour, Curaçao.—As an example of self-scouring harbours may be cited that of Santa Ana, Curaçao (Fig. 1, Plate 4), which is probably one of the finest natural harbours in the world. Behind it lies the Schottegat lagoon, a basin of water $2\frac{1}{2}$ miles in length, with a depth of 50 to 60 feet. The entrance is about 300 feet across, gradually widening into the Schottegat. Although the rise of tide is only about 3 feet, it would appear to be impossible for shoaling to occur with such a configuration and such depths of effluent water. Nevertheless the hurricane of September, 1877, produced a considerable and permanent narrowing of the entrance.

In many harbours expensive sluicing-basins have been constructed, and in France this device has been a favourite one. Where the entrance to a harbour is carried out direct into the open sea, the bed of which is sandy, it is hardly conceivable that artificial scour can be more than local in its effect, as the effluent runs out athwart the tidal currents, in relation to which its strength is insignificant. The velocity of the backwater is thus neutralized, and there follows a deposition of the materials in suspension and the formation of bars and shoals.

Ostend.—An ambitious sluicing scheme is now being carried out at Ostend, for particulars of which the Author is indebted to Mr. Van Gansberghe. A sluicing-basin 200 acres in extent is being built, and is expected to be finished in 1904.[2] The

[1] C. J. Minard, "Cours de construction des ouvrages hydrauliques des ports de mer." Paris, 1846.

[2] Minutes of Proceedings Inst. C.E., vol. cxxxvi. p. 298.

expense involved will be £108,000. The volume of water discharged will be 53 million cubic feet in 40 minutes; and the maximum velocity of the current along the new quay will not exceed 6½ feet per second. The object of this work is to scour and maintain a depth of about 26 feet at low water alongside the tidal quay, and also to carry to sea, in suspension, sand from other parts of the harbour. It is obvious that, as the velocity of the current is checked, the scoured material will be deposited again, and will have to be dredged. The special argument in favour of scour in this instance appears to be that it will reduce the number of dredgers in the harbour, where these vessels incommode traffic. The port of Ostend is a notable instance of a port dependent on dredging, where depths such as modern shipping requires have to be maintained. Up to the year 1890, the Stroombank, a long plateau of sand, having a flat gradient, formed a continually varying bar, covered to a depth of about 15 to 18 feet at low water of spring-tides (Fig. 2, Plate 4). The sand is of "ordinary coarseness," lightly covered with shells at certain places. Two suction-dredgers were set to work upon the west passage in 1890; the dredged material being carried about 2½ miles, and deposited on the north slope of the bank in 23 to 26 feet of water. The results attained were satisfactory, as the depressions formed fairly maintained themselves, the only encroachment being due to slips in the slopes. In the channel a depth of about 14 feet was thus secured by the removal of 448,000 cubic yards, at a price of 4·245*d.* per cubic yard. In May, 1891, a second contract, for dredging 327,000 cubic yards at 2·91*d.* per cubic yard, was let; and in October, 1891, a minimum depth of 16½ feet was thus attained. Dredging operations were then suspended for a year, and it was found that the deposit which had accumulated in the channel during that time was relatively slight. In September, 1892, dredging was recommenced at a cost of 3·4*d.* per cubic yard, the spoil being deposited in the Grande Rade, 2½ miles distant. In 1897, a fresh 5 years' contract for the maintenance of the west passage was let at 2·386*d.* per cubic yard. The material was deposited at a point north-east of the Nieuport Bank, 3 to 4 miles from the centre of the passage. By these operations a channel, 1,000 feet in width and 18 to 20 feet in depth, with entrance-mouths 1,600 feet in width, was obtained. The position of the west passage was determined on nautical grounds by reason of the existence of a relatively stable depression in the Stroombank, opposite the village of Middelkerke. It was subsequently determined to form a direct passage immediately to the north-west of the port. Although the

authorities realized that the effect of such works would be to augment the swell in the harbour, facility for the navigation of ships making the harbour from the open during storms, especially those from the north, was the deciding factor. A channel, 1,600 feet in width and 16 feet in depth below low water of spring-tides, has been created. The dredging was commenced in November, 1896, and the material, which here consists of coarse sand, was deposited near the Wenduyne Bank, 3 to 4 miles distant. The west passage has now been abandoned in favour of the direct passage. As it was found that there was a tendency for the tidal current running parallel to the coast, and between it and the Stroombank, to scour sand from the eastern end, and deposit it on the Petite Rade, the east passage was decided on, and has been dredged. The submarine strata consist of about 5 feet thickness of fine sand, pure at the west end, and silty at the east end of the channel. Below the sand is grey clay for a depth of 5 feet, and this rests upon very coarse sand with thin bands of peat. The amount of dredging necessary annually in order to maintain the port and its entrances is shown in the following Table:—

Locality.	Quantity Dredged and Price.		Depth Maintained below Low-Water of Spring-Tides.
	Cubic Yards.	Pence Per Cubic Yard.	Feet.
Entrance to Harbour	262,000	2·04	15
Interior of „	327,000	3·49	13
Direct Passage	327,000	2·04	18 to 20
East „	458,000	2·04	18 to 20
Total	1,374,000		

the passages, when a depth of about 15 feet is attained, the ment of the current accommodates itself to the altered rs, and there is comparatively little sanding-up. The Author een favoured by Mr. Voisin with the corresponding figures he port of Boulogne. In order to maintain the existing s, the following quantities have to be dredged annually:—

	Cubic Yards.
Interior Harbour	111,000
Exterior Channel of Interior Harbour	118,000
Exterior Harbour	471,000
Total	700,000

The whole art of conserving working-depths in and at the mouths of sand-threatened harbours lies in continual dredging. When a depth of 20 to 25 feet at low water has been attained by dredging, and a backwater, having a velocity of 3 or 4 knots per hour, exists, the problem is materially simplified.

Littlehampton.—At Littlehampton Harbour, in Sussex (the entrance to which is, however, almost dry at low water), permanence is secured by a high and solid windward pier about 600 yards in length, and a low and open leeward pier. On the windward side are sand-dunes, while the foreshore on the lee side of the harbour is sandy and flat; and the east pier is only about 100 yards in length, being prolonged a distance of about 550 yards by a low dicker-work groyne, having an average height of about 5 feet above foreshore-level. The piers are parallel. The flood-tide travels from east to west, flows across the flats, and, welling up against the west pier causes sufficient scour to dislodge accumulations alongside it. The River Arun also has a current of about 5 miles per hour at spring-tides and 3 miles per hour at neap-tides. The rise of tide is 16 feet at spring-tides and 12 feet at neap-tides, and vessels drawing 14 feet ascend the river to Arundel, 7 miles distant. The Owers afford the harbour some shelter from the westward.

The fineness or coarseness of the sand on a foreshore is an important factor in the travel produced by currents. For example, the Author finds that normal sand on the Bamburgh (Northumberland) coast gives a residue of 5·35 per cent. on a sieve of 2,500 meshes to the square inch, and on a 5,800-mesh sieve a residue of 39·25 per cent.; whereas sand taken from Hythe (Kent) gives a residue of 30·60 per cent. on a 2,500-mesh, and 72·75 per cent. on a 5,800-mesh sieve. Both sands consist of sharp siliceous particles. The former is a typical example of dune-sand. It is clear that a current which would move the former might have little effect on the latter.

Where waters are shallow, wind-waves in heavy gales plough up the sandy bed along a coast. This sand is kept more or less in suspension, is borne by the littoral currents, and is subsequently deposited over wide areas. Wherever an indentation or embayment of the coast-line or a harbour of still water occurs, a sand-trap is formed and shoaling results.

In deep water, under normal conditions of current, a totally different effect is produced. The current then traverses the surface of a sandbank, following the irregularities of its level, and causing but little disturbance. The small volume of sand in motion flows in a thin film over the surface of the sea-bed, and

drops to the bottom whenever the current is arrested by meeting dead water, or has its velocity reduced from any cause.

Action of Littoral Forces.—The action of the littoral forces under varying conditions is illustrated by *Figs. 3–20*. The effects of current only, disregarding wind, are shown in *Figs. 3–11*. It is assumed that the flood and ebb travel parallel to the coast-line and have the same velocity. The relative length and strength of tidal action in any given locality is a matter of actual observation at each spot, because the conformation of the coast-line and its geographical position are the governing factors. *Figs. 3–6* represent coast-lines where rivers debouch. In *Fig. 3* is shown a river-mouth where no attempt is made to regulate the silting action due to the tidal currents and river-outflow. In this case, according to the relative strength of the tidal currents and that of the river, a shoal will result in the centre of the fairway and at a greater or less distance out. A similar river-mouth having projected piers of equal length is shown in *Fig. 4*. The effect of these piers is merely to widen the foreshore and to carry the shoal farther seaward. *Fig. 5* represents a similar river-mouth with piers, one of which is longer than the other. In this case the lengthened pier carries with it a greater width of foreshore in rear, and some shoaling inside it. The outer shoal will be displaced towards the shorter pier. In *Fig. 6* is shown a similar river-mouth with piers, but with a protecting breakwater on one side of the harbour. In this case there will be a slow and progressive silting, forming a shoal between the breakwater and the nearer pier. Immediately inside the breakwater-head a slow whirlpool action will be set up. An island will result, surrounded by an in-and-out channel. The harbour shoal will form in a locality beyond that of the shoal in *Fig. 5*. *Figs. 7, 8* and *9* are intended as diagrams of harbours constructed in the open sea, without rivers, the general conditions of tidal action being as before. In *Fig. 7* is shown a breakwater having its length parallel to the tidal currents and running from a headland to shelter a roadstead. In this case a circular current will be set up as in the case shown in *Fig. 6*, and there will be progressive shoaling in the bay. *Fig. 8* represents a harbour with two enclosing breakwaters, the inner portions of which are in viaduct for a sufficient length to leave the littoral forces to some extent undisturbed. In this case there would be a thickening of the foreshore in [illegible] due to reflex action from the solid portions of the br[illegible] shoaling inside both these solid arms. *Fig. 9* r[illegible] ar harbour, but with solid breakwaters throug[illegible] nce accumulation will take place on the

Fig. 3.

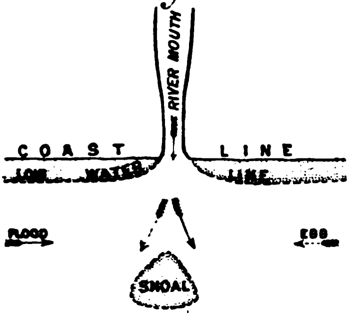


Fig. 4.

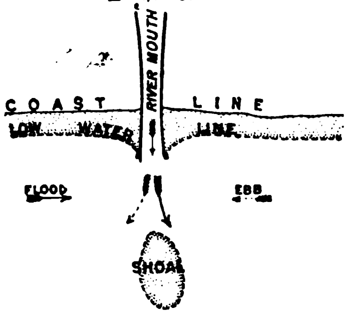


Fig. 5.

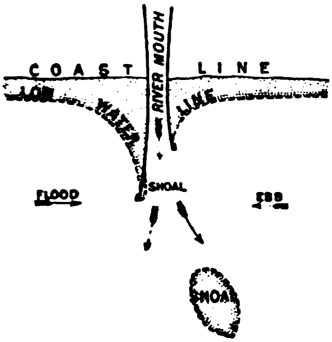
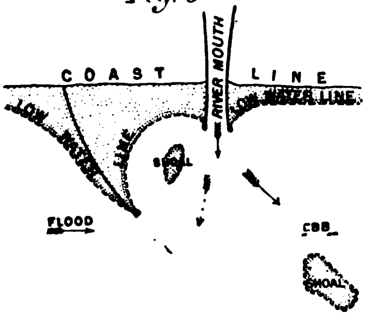


Fig. 6



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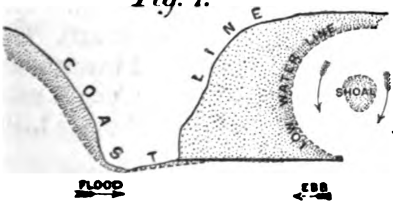

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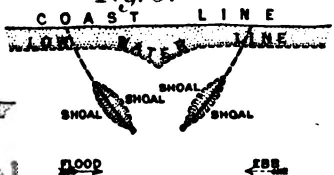

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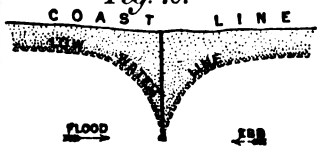

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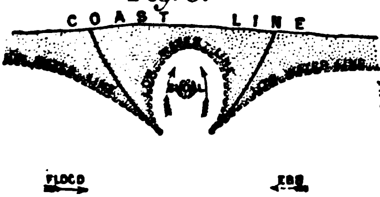
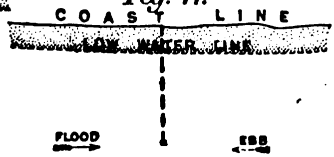


Fig. 11.



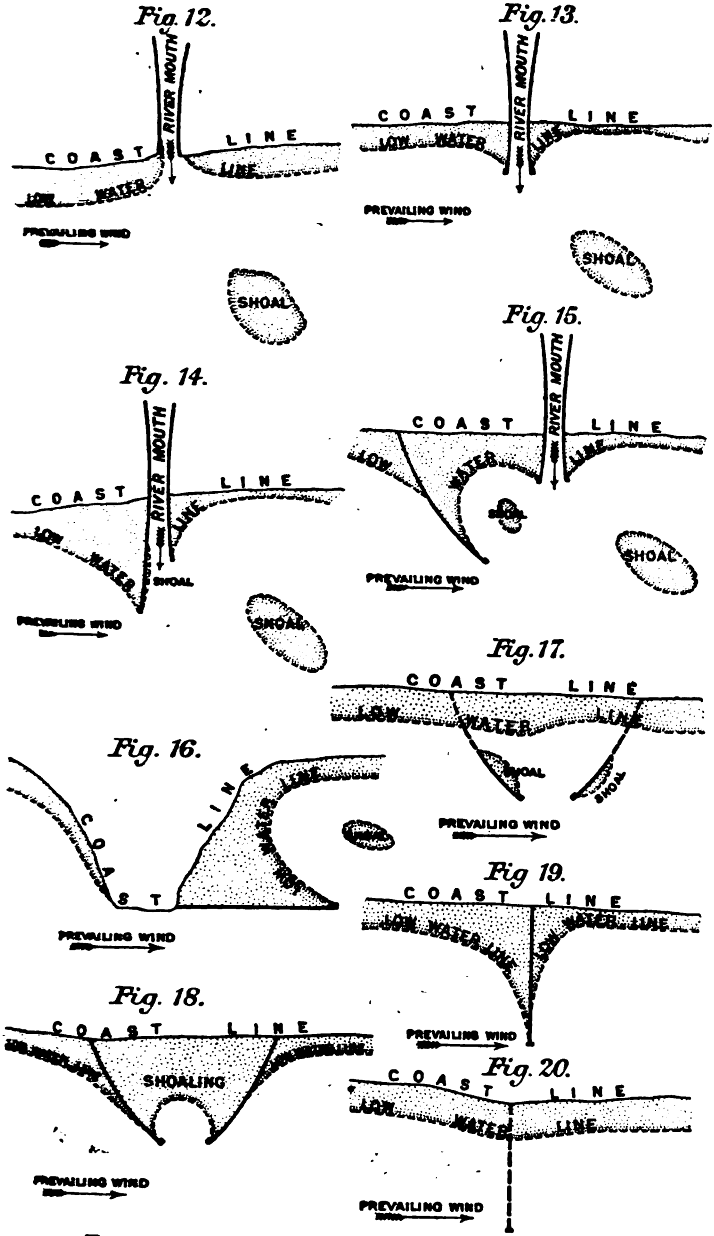
EFFECTS OF FLOOD- AND EBB-TIDES.

outer sides of both arms, and the whirlpool action, as in *Figs.* 6 and 7, will be set up, varying in direction with the flood and ebb. Inside this harbour there will be progressive silting. In *Figs.* 12-18 are represented similar harbours, with the action of the prevailing wind, in addition to that of the tides, taken into account. The effect in each case is to accentuate the conditions tending to shoaling on the weather side, with a corresponding scour on the lee side where the coast-line will be denuded or cut away. In *Fig.* 17 there will be some increase in the width of the foreshore, due to the shelter of the weather breakwater, under which the travel will slacken, and also some scour at the root of the lee breakwater.

Figs. 10 and 19 represent straight solid breakwaters or piers projected from the foreshore. In *Fig.* 10, where the forces are equal and opposite, shoaling will take place on both sides of the piers alike, and will result in gradual and permanent projection of the low-water line. In *Fig.* 19 a similar effect will be produced, but this, as before, will be greater on the weather side and less on the lee side. In harbours constructed on these lines the only cure for sanding-up is continual dredging, the volume of material dredged being in excess of that of the travelling sand. *Figs.* 11 and 20 represent viaduct piers. No change in the coast-line is caused by these structures.

Ceará Harbour.—The ease with which moving sand will sometimes outflank and overwhelm a solid obstruction built out from a tidal foreshore, even when an open viaduct intervenes, is startling. The most remarkable instance of this, to the Author's knowledge is that of Ceară Harbour on the north-east coast of Brazil. The construction of this work occupied about 10 years, and involved an expenditure of over £400,000. A viaduct 750 feet in length runs out from the shore and is prolonged by a solid breakwater 1,700 feet in length (Fig. 22, Plate 4).

The entire harbour is obliterated by sand; its investment is complete. The condition of affairs existing prior to the commencement of the works is shown in Fig. 21, Plate 4. This state of things was apparently normal and stable, although the "South America Pilot" (1885) states:—"The depths in the bay are said to be decreasing, and the foreshore advancing seaward." The coast-line lies approximately east and west, and to the east of the town are sand dunes attaining a height of 236 feet; in fact, the whole coast from Cape São Roque to Maranhão, a distance of about 600 miles, consists of sand dunes. From these dunes the prevailing wind carries vast quantities of fine sand. The sea-bottom forms



Effects of Prevailing Wind in Addition to Tide.

a comparatively shallow shelf, the depth being only about 30 feet at a distance of 3 miles from the town. Parallel to the coast-line, and about $\frac{1}{4}$ mile from it, are detached coral reefs, with a channel about 18 feet in depth intervening between them and the shore. According to the "Pilot," before the works were commenced, the harbour reef appeared at half ebb and formed a breakwater until half flood, after which the sea running over it caused a surf in which it was impossible for a boat to live. The rise of tide is about $8\frac{1}{2}$ feet. The great equatorial current flows steadily along this coast and carries sand in suspension, forming a belt several miles in width. In the light of accomplished facts, it is clear that the current circulating between the Great Reef and the shore was instrumental in maintaining the roadstead unimpeded by sand. The partial blocking and diversion of this current, due to the construction of the solid breakwater, had the immediate effect of causing the deposition of sand, and the extinction of the harbour. The familiar effect of erosion of the coast to the leeward of the harbour has also resulted at Ceará.

Madras Harbour.—No discussion of this subject, however superficial, would be complete without a reference to Madras Harbour. In designing the harbour, the late Mr. W. Parkes, M. Inst. C.E., appears to have adopted, as a measure of the sand travelling under the north-east and south-west monsoons respectively, the volume of sand caught by groynes on the coast; from the records of these he expressed the opinion that to fill a triangular area between the coast and a breakwater extending 1,200 yards from the shore, a period of 180 years would be required. In 1877, after 2 years' work on the north pier, the south pier was commenced, and was pushed on as rapidly as possible to intercept the sand-travel, as it was found that the quantity of wave-borne sand brought from the south by the south-west monsoon was nearly sixty times that brought from the north in the north-east monsoon. While great accumulations formed to the south of the harbour, to the north erosion took place; for 5 miles along the coast villages were cut away, and heavy revetments of rubble had to be made. Mr. F. N. Thorowgood, M. Inst. C.E., has favoured the Author with notes of his observations of sand-travel at Madras Harbour, from which it appears that the sand was wave-borne, and that an in-and-out movement of sand outside the surf occurred during the south-west monsoon in about $2\frac{1}{2}$ to 3 fathoms of water. During the period of his observation the sand was not in motion beyond the 4-fathom line. Sand-movements have, however, taken place up to the extreme depths of the harbour, as shown in *Figs. 23* and *24*. It

will be seen that, approximately, the $7\frac{1}{2}$-fathom line in 1879 became the 7-fathom line in 1890; that on the 7-fathom line of

Fig. 23.

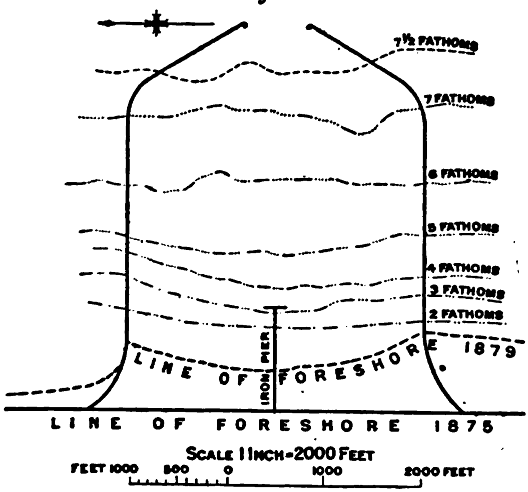
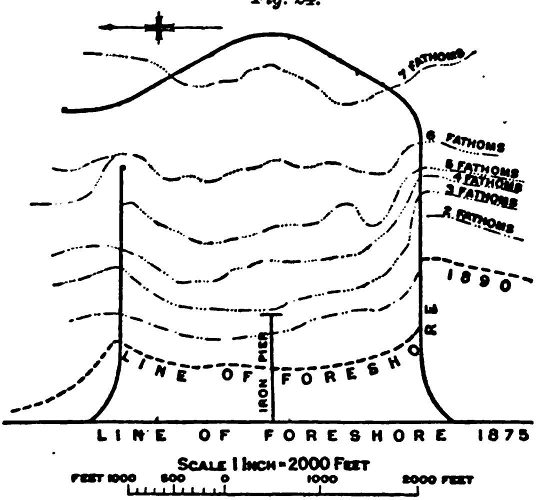


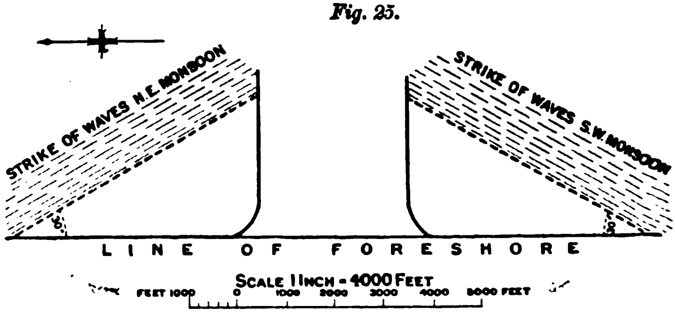
Fig. 24.



the former date there was only a depth of about 6 fathoms at the latter date, and that, correspondingly, the lesser-depth contours are pushed farther seaward.

Sir Andrew Clarke pointed out in his Report[1] to the Indian Government in 1879, that wave-force is the only scouring force of any practical importance at Madras. The tidal movement varies only to the extent of about 4¾ feet at spring-tides, and therefore success with any system of flushing-reservoirs is out of the question. He also pointed out that the local currents have a maximum velocity of only about 3 miles per hour, and that ships ride with their heads to the gentlest breezes, in whichever direction they may be blowing. In the south-west monsoon the lines of the crests of unobstructed waves approach the shore at a maximum angle of about 30° with the foreshore, and in the north-east monsoon at an angle of 30° in the reverse direction (*Fig. 25*). When the angle is at its maximum, the travel of sand along the coast is greatest, being, however, in opposite directions in the north-east and south-west monsoons. As the monsoons change,

Fig. 25.



the waves veer round, and for some time are dead on-shore, when the sand ceases to travel. Mr. Parkes's design provided for a single entrance 550 feet in width, the return ends of the piers making an angle of 30° with the foreshore (*Fig. 23*). This central entrance would appear to have been very generally condemned by nautical men, the safest course for ships entering the harbour being one parallel to the shore. On nautical grounds it was suggested that the northern arm should overlap the southern; but it is pointed out that this would probably convert the harbour into a sand-trap.

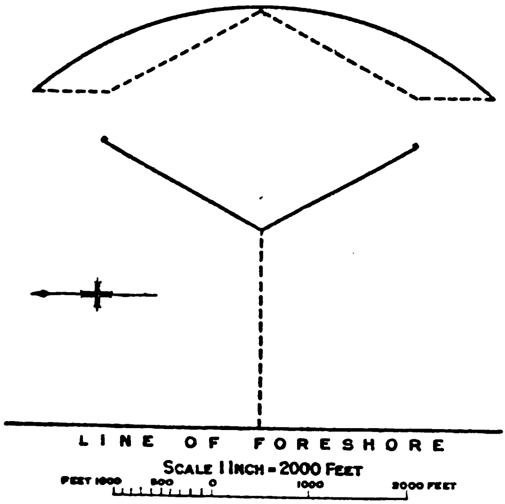
Sir Andrew Clarke's Report contains a review[2] by Major-General

[1] "Papers connected with the Construction of the Madras Harbour," p. 69. Calcutta, 1885. (No. ccvi. of Selections from the Records of the Government of India, P.W.D.)

[2] *Ibid*, p. 73.

(then Lieutenant-Colonel) C. S. Thomason, R.E., of alternative designs for Madras Harbour, in face of the unexpected difficulties which had arisen. During the north-east monsoon, when the waves were rolling past the point of the pier with their maximum sand-transporting power, the wave-force was resolved into two sections, one wheeling round the pier-head and creating an eddy in the angle formed between that pier and the foreshore. The action of the other component of the wave-force was less defined, but from the striations left upon the sand of the foreshore, it was demonstrated that the drag of the outgoing waves formed an angle of about 35° with the coast-line. The action of the south-west mon-

Fig. 25.



soon produced precisely the reverse effect. By a series of diagrams, General Thomason showed that the ideal design of a harbour in a situation such as that of Madras would be a diamond-shaped enclosure in deep water, having the major axis parallel to the shore and in length about double the minor axis, and having two entrances, one at each point of the diamond, sheltered by a length of breakwater running parallel to the coast-line. In order to avoid the creation of re-entering angles on the isolated outer arm, he finally suggested that this arm should be laid out to a flat curve (*Fig. 26*). Such a design, carried out to a depth of water beyond the travel of the sand, would obviously leave unaffected the coastal

travel of sand, northward or southward, according to the season. It might result in shoaling on the landward side of the inner arms, but the shoals would be of a shifting nature, and, if the work were carried out into sufficiently deep water, would not lead to permanent obstructions. It was suggested that the inner arm should be connected to the shore by an open viaduct, and that the outer arm should form a harbour of refuge pure and simple. With reference to this design, the Author considers that although such a harbour would no doubt overcome the difficulties of permanent shoaling, it is open to grave doubt whether as a harbour of refuge it would be really effective. The nautical evidence was to the effect that the only gales at Madras are cyclones, and it would probably be found that masters of vessels would prefer the security of the open sea to attempting to ride out a monsoon in such a harbour and without shelter from the wind.

In 1882 a Commission, consisting of the late Sir John Coode, K.C.M.G., Past-President Inst. C.E., the late Sir John Hawkshaw, Past-President Inst. C.E., and the late Sir George Gabriel Stokes, Bart., Hon. M. Inst. C.E., was appointed to report upon the best measures to be adopted for restoring the works. The principal points in their Report,[1] presented in January, 1883, were the recommendations to reduce the opening of the harbour from 550 feet to 450 feet, and to raise the breakwaters in mass-concrete from 6 feet 4 inches above the level of high-water of spring-tides to 12 feet above that level. In June, 1883, a mixed Commission, appointed by the Indian Government, further reported upon the harbour; and the design recommended by them is shown in *Fig. 24*. The following significant statement is contained in their Report:—

"No matter what the direction of the wind, the unceasing swell on this portion of the coast rolls in with the crests of the waves parallel, or very nearly so, to the coast line. In no case is it believed that the angle exceeds 30° to the general line of the coast. The result is that seas enter the present mouth freely, and, owing to the small length of the harbour, are not dispersed before reaching the shore at its base. The action is, of course, greatly intensified during storms, and particularly with the wind from the east. At such times the sea inside the harbour, though not so high as outside, is certainly of a dangerous character, being exceedingly broken. Taking these and other facts into consideration, the Committee have to record their opinion that unless means be found for closing entirely the present entrance, no radical cure will have been applied to the chief defect of the work as at present designed."

The following quotation from the observations of the Masters and Deputy-Master Attendants, is also given:—

[1] "Papers connected with the Construction of the Madras Harbour," p. 149.

"We consider that if the sea-face is closed, and a height of 12 feet given to the sea-wall, much of the character of a protective work to shipping, under which sanction to it was first obtained, will be restored, and the question of sending ships to sea on approach of bad weather need no longer be considered."

St. Catherine's Harbour, Jersey.—Another instance of the obliteration of a harbour by sand-drift is that of St. Catherine's, Jersey. This was the outcome of the defensive policy of the middle of the nineteenth century, and was commenced in 1848. The northern arm was carried out about 2,000 feet into the sea, but the southern arm was only built a short distance on the foreshore. Upon these works a sum of nearly £200,000 was expended. They are now sanded-up and abandoned.

Ramsgate Harbour.—The foregoing instances are of course extreme cases, but the history of a harbour like that of Ramsgate is an interesting object-lesson. The first Act of Parliament having reference to the Royal Harbour of Ramsgate was passed in 1749, and Smeaton makes the following comment on the result of the breakwater-building operations up to 1768, the works then being choked with sand and silt:—

"This struck the Trustees with so much chagrin, that in the year 1767 they made no visitation, and in their Report of 1768 they merely dealt with the construction of the piers without noticing the state of the harbour. This is the natural tendency of all harbours . . . the increase must take place, unless there are powers either natural or artificial to produce a contrary effect."

Smeaton predicted that instead of a receptacle for ships the harbour would become a field of corn unless recourse were had to such artificial means. He states that the sanding-up was at the rate of $\frac{1}{8}$ inch per week, the travelling sand being mixed with fine silt from the River Stour. Under his advice a sluicing-basin was constructed, but it was found to produce but little effect until a narrow confined channel or "flue" for its outfall was built. He subsequently reports a great improvement in the harbour. The harbour is maintained in its present condition as to depth by the annual dredging of about 100,000 tons, chiefly of very fine sand; and the erection of four new sluices has been determined upon, with the object of supplementing the dredging by sluicing. The Author is indebted to Mr. L. Longfield, Resident Engineer, for the foregoing historical details.

Harbours on the West Coast of Denmark. The history of recent proposals for harbours on the west coast of Denmark is instructive On the east coast the Danish waters are land-locked, and the main

problem is how to deal with interference due to ice. This is now practically disposed of by the use of powerful ice-breakers. On the west coast, at the extreme south is the harbour of Esbjerg, in which a depth of about 14 feet at low water is maintained. With this exception, and that of the western mouth of the Liimfjord, there is no sheltered water to which a fishing-boat can run for safety, and the result has been to place the Danish fisheries at great disadvantage. No doubt the rapid development of agriculture in Denmark in recent years has helped to divert men from the dangerous calling of the fisheries. A powerful Fishery Association has, however, been keeping the question of fishery-harbour accommodation to the fore. A scheme for a harbour at Hirtshals, to cost about £550,000, proved abortive. A solid pier running from the shore was commenced in 1879, but being heavily sanded up at a very early stage, the works were abandoned, except that on two occasions additional lengths have been added. Later, the Author advocated the utilization of Ringkjöbing-fjord, and subsequently prepared a project for an isolated harbour at Sandnæshage, where an extensive reef forms an effective shelter. In 1897 a Royal Commission was appointed to investigate the question, and their report is of an exhaustive character. The coastal conditions of West Denmark somewhat resemble those of Holland, and the risks of sanding are in evidence at every stage of the investigations of the Commission. Their decision was arrived at in 1900, and the Danish Parliament has now voted funds for the construction of a fishery-harbour at the Skaw, the extreme northern point of Jutland, and for building breakwaters, under the lee of which fishing-boats may take shelter, at Hanstholm and Vorupör respectively. It is proposed to run the former in a northerly and the latter in a north-westerly direction from the coast. The designs of the Commission for each locality investigated comprise the consideration of lee-breakwaters (*læmole*) and cover-breakwaters (*dækmole*) in every case. The former are detached piers approximately at right angles to the coast, the latter are island breakwaters running parallel to the coast in deep water, so as to be unaffected by the littoral drift (Figs. 30 and 31, Plate 4). The Government has decided against the latter type on the score of expense. The proposals of the Commission for the works at Hanstholm, Vorupör, and the Skaw respectively, are shown in Figs. 27, 28 and 29, Plate 4.

Conclusion.—Harbour enterprise has in general received little support from governments or municipalities. This is due largely

to the risks incidental to such work on sandy coasts.[1] A harbour when built has to be defended; moreover, it has to be maintained by dredging, often at a cost relatively high compared with the direct return which it produces as a trade centre. In the majority of cases the capital which it is necessary to sink in order to create local ports is too great to justify such costly projects. The Author submits that in view of these facts, which are common experience in every part of the world, a departure from established practice is called for. Harbours of refuge, so called, built in the open sea, and without shelter by high lands, have a limited range of utility. Masters of ships prefer the safety of the open sea, or to run to the shelter of a convenient headland, rather than to face the risks of making such a harbour in a storm. A ship riding at short anchor in such a harbour often experiences greater risk of the anchors coming home than the same vessel riding in the open sea with plenty of cable out. In the case of large townships on the coast, where no river accommodation exists, the Author's view is that in many instances a piled structure would supply all reasonable trade facilities. Such a structure, if carefully designed as to position and moorings, would be available for traffic in moderate weather; its first cost would be well within the resources usually available; and the cost of its maintenance would be trifling. It would produce no disturbance of littoral conditions, nor would it interfere with drainage-outfalls. The special points of design to be considered would be the height of the structure in relation to the waves, and the provision of such facilities for discharge of cargo that the handling of goods would be interrupted as little as possible by conditions of weather. The moorings and cranes would have to be of special design.

The Paper is accompanied by two sheets of tracings, from which Plate 4 and the Figures in the text have been prepared.

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[1] Complaints of apathy on this score are as old as the days of the Armada. See a rare tract entitled "A Discourse on Sea-ports, principally of the Port and Haven of Dover, by Sir Walter Raleigh, and addressed to Queen Elizabeth." Published in the reign of King Charles II.

Discussion.

The Chairman. The CHAIRMAN moved a vote of thanks to the Author for his Paper.

The Author. The AUTHOR suggested two points in particular which he thought might be discussed with advantage. It would be interesting to have, first, an opinion, from the nautical standpoint, of the value of harbours of refuge projected into the open sea, and unsheltered from the wind by high lands abutting upon them; and, secondly, an authoritative opinion as to the area of water which ought to be provided for vessels of the maximum draught—battleships, for instance—riding at anchor in partly-sheltered waters.

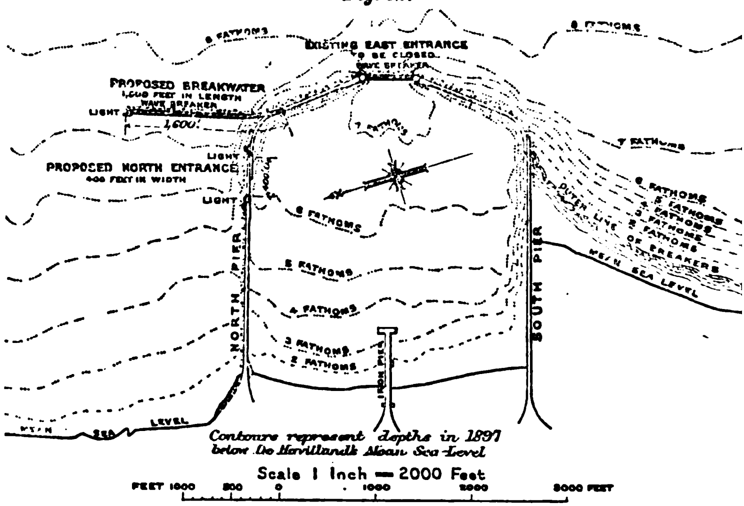
Mr. Matthews. Mr. WM. MATTHEWS (of Westminster) pointed out that *Figs.* 3–20 represented theoretically what might be expected to occur under the conditions indicated in the Paper. In looking at such questions it was important to take into account the particular physical conditions of each case. For instance, wave-force was the most effective influence in the movement of sand on beaches and in the vicinity of works; and at Dover, where the works had been going on for several years, the highest recorded wave measured about 15 feet from crest to trough. There might some day be an abnormal wave; but hitherto no wave of greater height than that had been met with. On the Tyne, however, where the work in connection with the North Pier had been in progress for about 5 years, the resident engineer had reported that he had measured waves of 35 feet and 40 feet from crest to trough; and Mr. Wm. Shield (of Westminster), had measured similar waves at Peterhead. The difference of the wave-force in those cases must materially influence the accumulations of sand in the vicinity of the works, and also the general configuration of the sandbanks under water. With regard to the currents and range of tide, at Colombo, where there was a considerable quantity of sand south of the harbour, the range of the spring-tide was 2 feet, and, as might be expected, there was very little current action. At Dover the range of tide was 18 feet 9 inches, and it was necessary to contend with currents of 4 knots per hour. With practically no current in the one case, and a current of 4 knots per hour in the other, there must be a considerable difference in the action of waves in the vicinity of the respective works. Striking instances of the effect of the

comparative volume of tidal water were afforded on the east coast, at Yarmouth and at Lowestoft. Both those ports were subject to the same wave-stroke and the same travel of beach; but there was a considerable difference in the volume of the tidal compartment and in the freshwater discharge. At Yarmouth there was a magnificent backwater, with tributaries running into it, which caused an immense discharge of tidal and fresh water—more than sufficient to keep open the harbour without dredging: in fact, during the 30 years he had known the place, the entrance to the harbour and its approaches had not been shallowing, but had been deepening, and there was a very active travel of sand. At Lowestoft, a few miles away, the harbour was kept open with difficulty, by almost continuous dredging; and this was due solely to the fact that the volume of tidal water was comparatively small. Wave-disturbances, current-velocities, and the volume of tidal water, were three very important influences governing the movement of sand; and they must be carefully taken into account before any opinion could be expressed as to what would take place at any particular point. The Author was quite right in saying that as embanking and reclamation proceeded, the channel shrank in depth; and all encroachment on the tidal compartment should in every case be jealously watched, and wherever possible ought to be prohibited. It was also true that, as the Author said, the whole art of conserving working-depths in and at the mouth of sand-threatened harbours lay in continual dredging. In illustration of this the cases of East London on the South African coast, and Durban on the coast of Natal, might be cited; they were probably two of the worst bar-harbours in the world, owing to the immense quantity of sand in motion. In connection with the development and improvement of their entrances, considerable expenditure had been incurred in carrying out internal training-works, and in the construction of moles. The moles and training-works had been effective to some extent, but both ports were kept open almost entirely by pump-dredging. At East London, when Sir John Coode first commenced work there, in 1877, the depth in the entrance was only 5 feet, and the rise of tide about 5 feet. Now the entrance had been improved to such an extent that vessels of 5,000 tons regularly entered and left the port. That result had been achieved mainly by pump-dredging, and it was the introduction of pump-dredging in 1886 that had rendered such improvement possible. Bucket-dredgers could not have worked in such a situation, in consequence of the wave-disturbance. The capacity of the first pump-dredger used

Mr. Matthews.

Mr. Matthews. at East London had been 450 tons, of the second 600 tons of the third 1,000 tons; while recently a new dredger, of 2,000 tons capacity, had been sent out. That showed what a development had taken place since 1886 in the size of pump-dredgers. A large pump-dredger could work when it would not be possible to use a small dredger, in consequence of sea action. Further much more work could be got out of it than out of a small dredger—an important point when the weather was favourable only for limited periods. With regard to Madras, he had had opportunities of obtaining information as to the situation there because he had had to work up, under his old chief, the late Sir John Coode, the investigations of two Committees, and he had been

Fig. 32.



a member of a Committee himself, with Sir Charles Hartley and Sir George Nares, in 1902. The present position of affairs at Madras rather differed from what was stated in the Paper; the Author's information was evidently based on what occurred in 1890, while Mr. Matthews's information was almost up to date. In 1902, the sand had gathered outside the knuckle of the South Pier, had passed along the outer wall of that pier until the entrance was reached, and had shallowed the entrance to the extent of 5 feet. In consequence of that action, and of the exposure of the harbour to cyclones, which rendered the harbour incapable of being used by shipping on such occasions, the harbour authorities at Madras, in conjunction with the chief engineer of the

Presidency, had proposed to close the existing sea entrance, to prolong the arm somewhat as shown in *Fig. 24*, but making the protecting arm 1,600 feet in length, so that it would be longer than shown in the diagram, and to leave an opening 400 feet in width further down (*Fig. 32*). The Committee had generally endorsed that proposal, and their idea in recommending the carrying out of those works had been that the sand would travel along the back of the new work. This it would do shortly, as soon as the entrance was finished: some of it would pass northward, and resume its normal travel along the northern foreshore; but a portion would be lodged as a spit under the lee of the new east breakwater, where it could readily be dealt with by means of a pump-dredger working in shelter. There was no doubt that plan was quite feasible. Figures in his possession showed that 550,000 tons of sand would have to be dealt with annually; and that quantity had really been the foundation of the whole investigation with regard to a remedy. If not more than 550,000 tons of sand passed along the back of that work, and a portion of it went forward, then it would be necessary only to deal with the balance by dredging under the lee of the breakwater, which could easily be done by a modern pump-dredger. Mr. Matthews.

Mr. J. C. Hawkshaw, Past-President, mentioned that in 1874 his father, the late Sir John Hawkshaw, Past-President Inst. C.E., had personally inspected and reported on the principal harbours of the coast of Brazil, from Maranhão in the north to Porto Alegre in the south—among them the port of Ceará. The work carried out at Ceará as shown in Fig. 22, Plate 4, appeared to be almost identical with the plan which had been given in Sir John Hawkshaw's report, and therefore he wished to place it on record that his father's connection with Ceará had ended with his report. He had not been consulted about the work carried out there, and had had nothing to do with the works described in the Paper. On a coast subject to variable currents and drifting sand, it must always be doubtful what the effect of any proposed plan would be; and the best-considered design might require modification in execution. The responsibility for making the necessary alterations rested with those who carried out the plan, and they could not be avoided by following the plan of another engineer. He felt sure that his father, if he had had the carrying out of that work, would have modified his design when the effect of the work on the travel of the sand became apparent. Mr. Hawkshaw.

Mr. C. B. Case could not agree with the Author that if the wind was dead on-shore steep slopes of shingle and flats of sand Mr. Case.

Mr. Case. resulted, whereas if the wind struck the coast obliquely the shingle was dragged down to a long slope. The average angle of repose of a yielding beach depended mainly on the bulk, shape, and specific gravity of the particles of which it was composed; but that angle necessarily varied in harmony with changes in the action of the waves and currents. Those changes might be communicated from a distance, but they were more pronounced when arising from an alteration in the direction of the local gales, which raised the heaviest seas. An on-shore gale, therefore, affected the beach quite differently from one that struck the coast obliquely; but the difference was not that suggested by the Author. It was the on-shore gale that caused the beach to be dragged down to a longer slope; and this for several reasons. In the first place, the more the wind blew behind the waves, the more they skimmed the surface of the beach as they plunged, and the farther they projected their wash upward. Moreover, the wash flowed directly up the beach instead of in a slanting direction, as it did with oblique waves, and its upward progress was further assisted by the wind. The result was that the fetch of the wash attained its maximum when the wind was dead on shore, and its planing-action was consequently then most developed. Further, the wind drifted the surface-water towards the land, and there banked it up —especially between converging coasts—until an undercurrent was forced out seaward, which tended to flatten the beach still more. Waves that struck the coast obliquely produced a travel of material coastways; but the movement between sea and land was proportionally diminished. He did not follow the Author's statement that ground-swell and tides were much ke in their action, both producing terracing. He was under impression that the production of terraces had nothing to with the presence or absence of ground-swell, though of se their production was favoured by changes in the level he tide. Any fair-sized wave would throw up a "full" of erial, the position of which marked the highest level attained the wash; terraces were simply a series of such "fulls," anged in different positions corresponding to changes in the rm of the beach, the height of the tide, and the action of the ash. A plentiful accumulation of shingle in a tideless sea would usu bit a "full," marking the limit of the wash during the s. Below that there would be another "full," the wash for the time being; and there might intermediate "fulls." The effect on the same ction of tides, would be to increase the number of

"fulls," in consequence of the variation in the level of the waves at the time of high tides. *Fig. 8* was somewhat puzzling. What was the reflex action referred to, and why was there no accumulation around the ends of the breakwaters, the supports of which must to a certain extent retard the travel of material? The waves, running more or less alongside the breakwaters, were travelling towards the beach. How were they reflected from an obstruction against which they were not impinging? There could be no mutual reflection between the breakwaters and the beach, for there the energy of the waves was completely converted. With the balance of littoral forces which the Author had assumed, Mr. Case would have expected accumulation around the open ends of both breakwaters. The accumulations within the harbour would merge into each other more or less, but in any case they would exhibit concavity rather than convexity opposite the entrance of the harbour. It seemed that in the majority of harbours the deposition of current-borne sediment was chiefly effected within a comparatively small area dominated by the eddies just inside the heads of the breakwaters. A shoal was there formed, which was prevented by the action of the waves from rising above a certain level. Thus, material was almost continually falling on the shoal, and was spread abroad by the waves until it gradually settled in various parts of the harbour where, in the absence of scour from behind, the water was sufficiently quiet to afford it permanent refuge. That suggested the possibility of controlling the material deposited in the shoals, so as to prevent it from spreading over the harbour. What, for example, would be the effect of connecting the two breakwaters by a submerged vertical barrier, springing from them immediately behind the shoal-area, and bulging seaward, so as to project beyond the harbour-entrance? Presumably, without coming too near the surface, a barrier of that kind could be erected of such a height that the silt banking up in front of it would, before rising to the level of its crest, tail off so far seaward as to project well beyond the harbour, where it would be sufficiently exposed for its further growth to be restrained by natural forces. Mr. Case.

Mr. W. H. Hunter thought it would be agreed that the Paper was valuable in the sense that it would be likely to lead to thoughtful consideration of the subject. Had the principles laid down by the Author been understood and acted upon, a great deal of trouble would have been avoided, and expenditure saved, in connection with the attempt to form a harbour on the Caribbean coast, for the Nicaragua Canal. There, all the conditions described by Mr. Hunter.

Mr. Hunter. the Author obtained, in spite of which an abortive attempt had been made to construct a breakwater. A short length of breakwater had been run out, with the inevitable result that the sandbanks had overtaken it. Attempts had then been made to prolong the breakwater, but as fast as it was constructed the banks of sand had projected still farther; and so matters would have gone on indefinitely had not operations been wisely brought to an end. He ventured to suggest that the opening sentences of the Paper contained a contradiction of terms. The Author stated that on a tidal foreshore when the balance of the littoral forces was disturbed by solid works, especially when moving sand was present —that was the key-note of the Paper—an alteration of the contours of depth followed as a natural consequence. The presence of moving sand demonstrated that no balance of forces existed. Where there was equilibrium there was no movement: where there was movement there was lack of equilibrium. The forces which prevailed—the forces which the Author called "littoral"—were effects of the operation of two great laws, one, the law of gravitation, acting directly upon the particles of sand and shingle and also producing tidal and atmospheric action; the other, the law of centrifugal force, causing wind as the earth revolved upon its axis. That criticism, however, did not affect the conclusions at which the Author had arrived; it indeed rather added force to those conclusions.

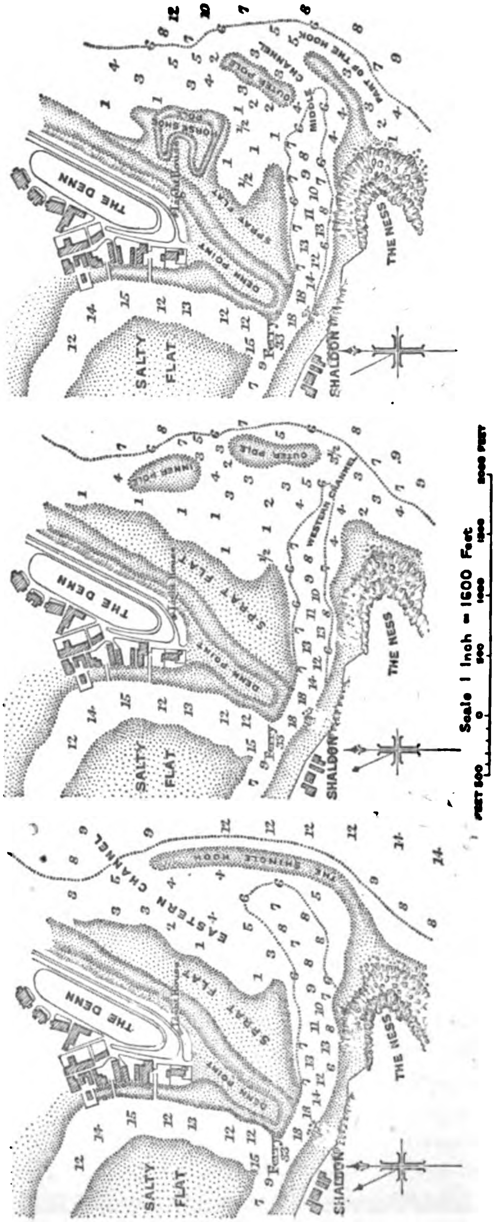
Commander Frederick. Commander G. C. Frederick, R.N., observed that there were doubtless cases in which there must be a conflict of opinion as to the best form of harbour-entrance from engineering and navigational points of view; and often the result had to be a compromise. From an engineering point of view a harbour might be perfect, but if it could not be used for navigation it would be useless. One of the most important questions for discussion was the direc-
the entrance, and Madras Harbour was a case in point.
navigational point of view it had been desired that the
should be as depicted in *Fig. 23*, namely, straight out
At the entrance to the Tyne there were two piers
straight out to sea, and vessels could enter safely under
itions of wind and weather. But a harbour-entrance of
scription was not suitable at Madras, because it caused the
ır to silt up; and other forms had had to be designed,
bly that described by Mr. Matthews (*Fig. 32*). Even from a
vigational point of view that seemed to be a sound plan, because
n under the lee and enter with greater ease than
h such an entrance as was shown in *Fig. 23*.

With long narrow ships, there was considerable difficulty in entering a harbour where the tidal current set directly across the entrance. If the entrance was narrow, as soon as the vessel's bows were inside, the fore end of the ship was in still water, while the after end was exposed to the full force of the current; and she might be twisted rapidly out of her course, with considerable danger. Where it was possible to enter under the lee, as in *Fig. 24*, it would be safer to do so. The space required by battleships depended upon circumstances. In a narrow harbour where ships were exposed to strong winds, they might want a large amount of cable out if they used their own anchors and thus occupied considerable space, even allowing for smooth water. But in an enclosed harbour with moorings laid down, as was being done at Dover, the ships could swing at their moorings, and less space would be required. Large harbours in which ships could veer their cables in bad weather were advantageous; but in confined harbours, like Malta, where there was very little room to spare, it was more a question of the strength of the moorings than of the space in the harbour. Commander Frederick.

Mr. J. C. INGLIS remarked that any attempt to formulate general principles in connection with harbour-engineering must be interesting to members of the Institution. At the same time, Mr. Matthews had given a useful word of caution in saying that every case must be dealt with on its merits. *Fig. 14* reminded him of the conditions of the harbour of Teignmouth, which had been left entirely to itself on account of want of funds. He had examined the harbour and the reports made on it by several eminent engineers, from 1821 onward, and had noticed a curious cyclical change in the conditions. The configuration of the harbour was similar to that shown in *Fig. 14*, as would be seen from *Figs. 33* (p. 240), which represented three successive stages in the cyclical change. There was an abundant discharge of fresh water, and also a strong tidal discharge. The prevailing drift was coastways, and the preponderating wind from the south-west. With a strong outfall of tidal and fresh water, the conflict of currents had tended to a deposition at the Hook, which had extended to 700 yards; and periodically the depth of water over the bar had gradually diminished from what might be said to be its normal depth. Sometimes suddenly, as the result of storms, at other times gradually, the bar or natural breakwater formed by the Hook had extended, deflecting the outfall to the north. This deflected current, as *Figs. 33* showed, had gradually deposited material at the outlet of the extended Hook. The process had gone on until the entrance to the Mr. Inglis.

Mr. Inglis.

Figs. 33.



PLANS SHOWING MOVEMENTS OF TEIGNMOUTH BAR.

harbour was seriously blocked, and then, generally suddenly, the Hook had been broken through, and a direct entrance obtained to the harbour. Captain Spratt, a careful observer, noted in 1853 that the complete cycle of these changes had taken place in 7 years; but even this period depended upon prevailing winds and periods of storm.[1] A very interesting report on this harbour, made by Sir John Rennie in the year 1838, was well worth quoting, as showing the result of his investigations in that year, and as explaining the above phenomena, which then caused the Commissioners to apply to him for advice. Describing the history and configuration of Teignmouth Estuary Sir John Rennie said:— Mr. Inglis.

"The southernmost point of the Den had been considerably reduced in length and height, and was beaten down by the violence of the waves, so that the waters of the Teign, instead of issuing in one combined and uniform mass, so as to enable them to act in the most effective manner in resisting the opposite and more powerful action of the sea and wind from without, were dispersed over a large area, and thus their force was considerably diminished, and became incapable of maintaining a deep and direct channel to seaward, and were necessarily compelled to run parallel to the shore until they had acquired sufficient force to discharge themselves, and in this manner the bar may be said to be in a continual state of change. When the easterly winds prevail then it extends a considerable distance along the shore from the Ness in front of the Den; when the westerly winds prevail, then the Teign, being protected at the mouth, naturally takes the most direct course to seaward; the southern part of the Den accumulates both in length and height, and forms, as it were, a pier or breakwater to quiet the waters issuing from the river in the most beneficial direction, and the bar is then considered to be in the best state, the entrance being close to the Ness, so that depending upon either of the above causes the bar and entrance is confined to a range of about ¾ of a mile."

This showed that sandbanks did not always behave in the manner suggested by *Fig. 14*. They had a way of demonstrating that there was no equilibrium in sea-coast matters. Teignmouth Harbour was not large; but he thought it was well worthy of closer study, as an example of what happened when a harbour with ample scour was left entirely to itself. Ceará Harbour seemed to bear a striking resemblance to Rosslare Harbour, with which he had something to do. There the principle of an open viaduct running out to a solid breakwater, placed exactly as shown in Fig. 22, had been entirely successful. That was another example which supported Mr. Matthews's view that each case must be judged on its merits.

[1] T. Spratt, "An Investigation of the Movements of Teignmouth Bar." London, 1856.

Dr. Owens. Dr. J. S. OWENS considered that a current flowing in simple stream-line motion, which rarely occurred, had no power either to lift material or to hold it in suspension. Therefore it was necessary to look to eddies and irregularities in the motion as the means of keeping material in suspension. Consequently, if a current were flowing whose velocity remained the same, but which at one place traversed broken water, and in another passed into sheltered water, it would seem that the current should pick up material in the disturbed part and deposit it in the sheltered part. The bearing of that conclusion upon a harbour affording free ingress and egress for currents was obvious, as the part sheltered by the harbour would allow deposition. The question arose, was it possible to utilize that principle by producing eddies artificially and causing a picking-up of material where it was desired to produce scour or erosion. He knew of cases in which depositing rocks and loose boulders on the foreshore, with a view to protect the beach, had produced the reverse effect, presumably because the eddies had caused the material to be picked up. Again, it would seem to be a logical inference that, in order to prevent erosion, the bottom should be kept as smooth as possible—more especially in the shallow water on the foreshore—and all projections and abrupt changes of contour shonld be avoided. The principle appeared also to have a bearing upon the spacing of groynes. It would be possible to space groynes so close together that any current passing over them would be sufficiently disturbed to prevent the deposition of material. An interesting case similar to that of Teignmouth Harbour was the outfall of a small river at Heacham, on the coast of Norfolk. At one time the river, which was not of much commercial importance, had its outfall at right angles to the line of coast, while the present outfall was nearly 2 miles farther south; and the river was separated from the sea by a narrow sandspit not more than 40 to 50 yards wide, and between 1½ mile and 2 miles long. The cause of that was obviously the drifting of the material from the north. The preponderance of the tidal and littoral forces producing drift from the north over the force of the outflow from the small river, was so great that the spit had gradually grown southward, and had diverted the course of the river. The production of the spit, however, had increased the extent of the tidal basin, and the much larger outfall which consequently took place at every tide had restored the balance, so that the spit was no longer growing, and a great deal of erosion round the point of it was taking place.

Mr. F. N. THOROWGOOD had been engaged on the Madras Harbour works between May, 1876, and September, 1888, and he was glad to have an opportunity of making a few remarks, chiefly on the movement of sand and the difficulties to which it had given rise in the construction of the harbour. The sand that obstructed the Madras Harbour was almost entirely wave-borne, although those who criticised the harbour constantly talked of the sand as being borne by the currents. Many years' observation had shown him that very little sand was borne by the currents, and that nearly all of it was thrown up by the waves. The rapidity of deposition, and the enormous quantity thrown up during the south-west monsoon, were almost incredible. The following was a short account of the first Madras harbour-works:—When he arrived at Madras early in 1876 an endeavour was being made to start one of the arms by tipping rubble in order to advance the concrete block-work. The tipping began with great energy at the beginning of the south-west monsoon, and he found that, instead of getting to the place to start the block-work, the difficulty was to get to the water at all, the sand advancing so rapidly that the work was always in the dry. An enormous quantity of stone was brought down, four trains per day each carrying 320 tons of it. Eventually, when the sand had reached a certain height, there came a very high surf which knocked the surf-bank to pieces. He instantly began to set concrete blocks on the top of the ruined bank, and then the interval between the monsoons occurred, and the sand did not accumulate further. By that time the people of Madras had become alarmed, thinking that the sand would soon get higher up, and that eventually, instead of a harbour, there would be a great spit of sand. The Government requested Mr. Parkes to see whether the advance of sand was not more rapid than he had anticipated. The small groynes which had been put up by the Government along the coast on the north allowed much sand to pass them; and Mr. Parkes had to qualify his original estimate that it would be 160 years before sand would begin to turn the corner at the bend of the south pier. He had no record of Mr. Parkes's modified estimate, but he thought it was about 90 years, so that the matter would give no trouble to the present generation. The object was to run out the south pier so quickly as to anticipate the sand before it got inside with the south-west monsoon. Fortunately that was done, and apparently all that remained was the sand permanently imprisoned between the two piers. The work progressed to a certain point, and then arose another trouble with the sand, which he had referred to in

Mr. Thorowgood.

Mr. Thorowgood. the Institution 22 years ago.[1] When the concrete block-work had reached what was then the 4-fathom line, and was now 2 fathoms, the whole of the rubble base was one day covered 8 feet deep by very fine sand. He tried all sorts of plans to get through it, and finally by sinking an iron caisson in front of the blocks, excavating the sand with a kind of dredger, and setting the blocks on the top of the rubble inside the caisson, some slight progress was made, until one day there came a cyclone which disturbed the whole water of the Bay of Bengal, and swept away all the sand and the caisson, but did not disturb any blocks. After that, there was no more trouble with sand in the foundation, but in the following year the same thing happened at the corresponding point on the south pier. He pushed through it in the same way, and there was no more trouble there. He tried experiments by putting in some iron tanks at 4 fathoms, 6 fathoms, and 7½ fathoms. They were about 3 feet 6 inches cube, with a hole in the top. They were very carefully set, by observations, on the sea-bottom, in a line with the pier, and were periodically examined by a diver; and there was always found underneath the hole a small heap of fine sand, which showed that some sand was coming in from the Bay of Bengal, and apparently also coming in towards the harbour. That, however, was quite different from the sand which kept heaping up against the south pier. The original design of the harbour had the arms at right angles to the main piers, and the entrance 450 feet wide; but as the work went on the Marine Department thought there would be a better entrance if they were sloped, and therefore the arms were sloped (*Fig. 23*) and the width of the entrance was increased to 550 feet. The work went on well until 1881, and both piers were got out to the two pier-heads; then the public considered the harbour finished, and many sailing ships used to come in and anchor. He had seen as many as twenty-two native craft anchored, and a large full-rigged ship there also. In the meantime he was putting down screw-moorings for steamers, according to the orders he had received, and also levelling up and making a kind of quay-wall. But on the 12th November, 1881, a terrible cyclone occurred. He had been on the Tyne Harbour for a long time, and had seen much larger waves at the mouth of the Tyne than were seen in that cyclone, which knocked over the ends of the breakwaters of the Madras Harbour; but he had never in his life seen such a

[1] Minutes of Proceedings Inst. C.E., vol. lxx. p. 36.

Mr. Thorowgood.

confused sea. There was no lee side; the waves came from every direction, poured over both breakwaters, and, rushing through the entrance, knocked over into the harbour large portions of both piers, leaving the bottom blocks. The damage done by this cyclone was almost as interesting as it was disastrous. From the end of the curved work outward, in both piers, the blocks (weighing 27 tons each) were knocked over into the harbour; but along the curved work (also on both piers) the eddy of the confused seas undermined the walls, and all the blocks fell over outward, namely towards the attacking waves. This was an extremely important point to notice. The putting-down of the screw-moorings was done by having the screwing-apparatus between two hopper-barges fastened together, which deposited the rubble base. The harbour was practically finished, and the entrance was of its final width; yet the whole screwing-apparatus was nearly carried away by the send of the waves inside the harbour. According to formula a 10-foot wave should have become a 2-foot wave by the time it reached the full width between the piers; but as a matter of fact, the wave was 3 feet high there, and that wave, travelling onward and getting into shallow water, caused a good deal of trouble and made it very difficult to put down moorings. If there was much swell outside, the water inside was not smooth. Such was briefly the history of the first harbour constituted at Madras. One of the difficulties had been to prevent the tremendous erosion which had occurred on the shore about 3½ miles north of Madras. Villages, almost towns, and sacred burial places of natives had been washed away, and the only course had been for the Government to buy the land and let it be washed away. Every sort of protection had been put down. Groynes had been useless, because there had been nothing to catch; the harbour had caught everything. That had added a great deal to the worry and trouble of carrying out the work. By the courtesy of Sir Alexander Rendel he had recently seen the latest soundings at Madras, at the entrance. Whereas, according to the last survey made by him, in 1888, the contour-line at the site of the entrance was 7¾ fathoms, it was now only 6 fathoms. Whether the sand which had filled up the entrance was what had got round the end he was not quite sure, because here another factor came into the question. In the Bay of Bengal there was an almost ceaseless surf. The Home Committee which reported upon the Madras Harbour in January, 1883, recommended, among other things, the raising of the two breakwaters. Before that was done, in anything like a sea the water used to pour over the breakwaters

Mr. Thorowgood. in cascades, so that it was extremely dangerous to go along them, and many men were washed away and drowned. The result of that constant falling-over of water into the small enclosure was to make the level of the water inside much higher than that of the water outside, and there was always a strong outward current at the entrance. He believed it was this action which had kept the entrance about the same depth as at the beginning; and Sir Alexander Rendel had told him that the two breakwaters had been raised 6 feet, and now nothing like so much water came in. The water inside was consequently not much higher than the water outside, and there was less scour at the entrance. He could not help thinking that the enormous silting at the entrance was as much due to that fact as to the advance of the wave-borne sand. Every one had been disappointed that when the first harbour was finished up to the entrance, the result with regard to smoothness of the water inside was not as good as had been hoped for. In 1882 he came home on 12 months' sick-leave, and in 1883 a Committee, consisting of Sir John Coode, Sir John Hawkshaw, and Sir George Gabriel Stokes, considered the question of restoring the damaged part of the harbour: they recommended raising the breakwaters and strengthening them with random blocks outside, but they did not recommend altering the entrance. In 1883 he was in Madras again and found that Lieutenant-General Sir Richard (then Colonel) Sankey, was very anxious to alter the entrance so as to prevent the swell from coming in. Later on, Mr. Thorowgood sat on the Committee which proposed a design similar to that shown in *Fig. 24*, involving the closing of the eastern entrance and the formation of an entrance on the north side. No sand came from the north and there was no fear of silting there. He did not think that plan was good for navigation, and he would not like to be a skipper bringing in a ship with an easterly swell; it would, however, have given smooth water. But it was not done, as his orders were to go on rebuilding according to the plans. In the meantime the works had been taken from the Government and put under a Local Board, and they appealed home and said they must have the eastern entrance closed. Another Committee sat, consisting of Sir Nowell Salmon, Sir George Nares, and Sir John Coode. Their report was in favour of closing the eastern entrance if the sand appeared to advance more rapidly, not, however, of closing it at once, but simply of stopping the north pier in its rebuilding, while pressing on with the south pier. Evidently that had not been carried out, because both piers had been gone on with and had been got into the shape

shown in *Fig. 23*, with what result he did not know, except the silting-up of the mouth, which he was inclined to think was largely due to the want of the scouring action which formerly resulted from the sea pouring over the two breakwaters and filling the harbour to a higher level than the water outside. Major-General Thomason, who was very much interested in the matter, was sent by Sir Andrew Clarke to examine the movement of sand. His investigations were elaborate and interesting, and he evolved out of them the design of the harbour shown in *Fig. 25*; but how on that plan goods were to be got from the ship to the shore Mr. Thorowgood did not know. No doubt a sand-pump dredger would, as Mr. Matthews had stated, be alright under the lee of the breakwater, but it would have a bad time if there was any swell coming in. A sand-pump dredger was on its way out to Madras, to dredge the opening, in the hope that things might be improved thereby. Mr. Thorowgood.

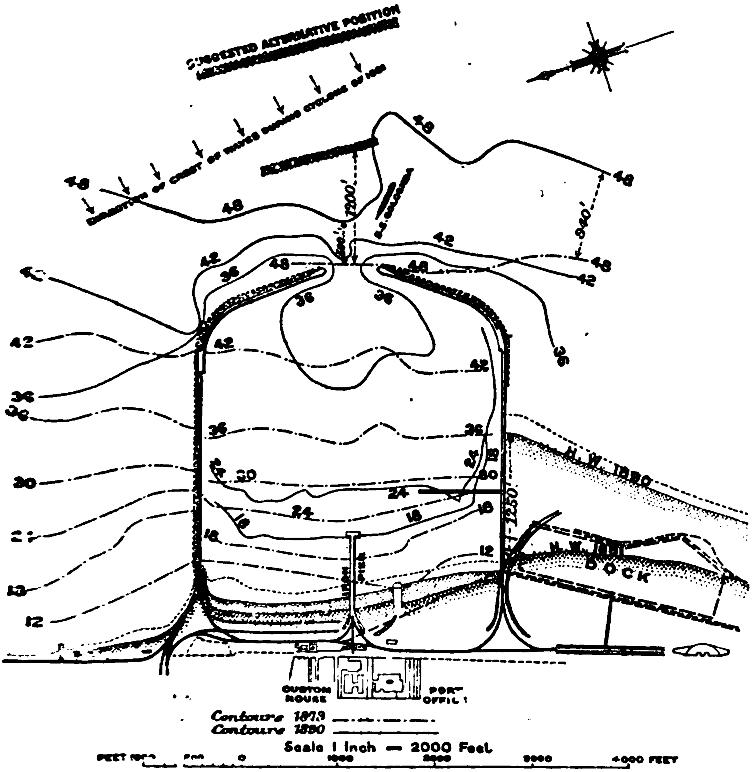
Mr. J. M. Dobson stated that in 1901 the Madras Railway Company were approached by the Madras Chamber of Commerce with reference to the various improvements proposed for the harbour, with the idea of obtaining their support; and, in consequence, Colonel Gardiner, the Chairman of the Company, called upon Messrs. Hawkshaw and Dobson to report upon the whole question, which they did in November of the same year. The subject was by no means a new one to them, because in 1883 the late Sir John Hawkshaw had reported, jointly with Sir John Coode and Sir George Gabriel Stokes, as to the best method of restoring the breakwaters which had been partly destroyed by the cyclone of 1881. No doubt Mr. Parkes had considered, from the information at his disposal in regard to the travel of sand, that the accumulation would be very small, and, in consequence, started the north breakwater before the south, a circumstance which had always been difficult to understand. It was stated in the Paper that the south breakwater was not started until 2 years' work had been carried out at the north breakwater, but he thought the Author was misinformed on this point, because in a valuable report[1] made by Sir Guilford Molesworth in 1882 it was stated that the north breakwater was started on the 17th December, 1876, and the south breakwater on the 19th November, 1877, an interval of only 11 months. Yet in this short period, according to Sir Guilford Molesworth, a very large accumulation of sand took place in the harbour itself, owing to the north breakwater Mr. Dobson.

[1] "Papers connected with the Construction of the Madras Harbour," p. 110.

Mr. Dobson. having been started before the south. From Mr. Thorowgood's observations it appeared that the sand at Madras was wave-borne, and that an in-and-out movement of sand outside the line of surf took place during the south-west monsoon in 2½ to 3 fathoms of water; while Sir Andrew Clarke pointed out in 1879 that the wave force was the only scouring force of any practical importance at Madras. Admitting that the sand was wave-borne, and that the current was only 3 miles per hour, but bearing in mind that it ran from south to north for 7 months of the year, he did not think anybody could look at the plan of Madras Harbour which he had put upon the wall (*Fig. 34*) without coming to the conclusion that the 3-mile current had a great deal more to do with the silting-up at Madras than many supposed. On the plan were marked the foreshore in September, 1881, and the foreshore in 1890; and it would be observed that by 1890 the foreshore had come forward no less than 1,250 feet, so that where in 1879 there were 36 feet of water, on the south side, there was now high-water mark. On the south side of the harbour the 8-fathom line had come forward 940 feet, while at the entrance it had only come forward some 500 feet. He thought there would be no difficulty whatever in keeping the harbour open, as well as the entrance, by using a suction-dredger of moderate size; because, taking 5 feet as the depth of silting over the whole area between 1879 and 1890, it meant removing 15,000 cubic yards per month. With a dredger lifting 4,000 cubic yards per day that could be done by working 4 days per month; and even taking Mr. Matthews's figure of 550,000 tons, which was about 458,000 cubic yards, or 38,000 cubic yards per month, the same dredger would deal with that in 10 days. Therefore the question of silting had been largely magnified with regard to Madras Harbour. He agreed generally with the Author's remarks as to silting, but held that special circumstances might alter the application of general principles. In the River Plate he had seen large quantities of sand being carried in shallow water with a 3-mile current. The waters from the Paraná brought an enormous amount of sand, which was carried in suspension along the bottom, passed down the river in front of Buenos Aires, and was dispersed over a large area; and that had gone on, to his knowledge, for 10 years without diminishing the depth of water in the river to any appreciable extent. But no sooner was a channel cut—no matter how obliquely it was put to the current—or groynes projected or breakwaters built, than the presence of the sand was immediately felt. The Madras Committee of 1883 suggested in their report

that the eastern entrance should be closed and that another entrance should be made as shown in *Fig. 24*; and that report was submitted to Sir John Hawkshaw and his colleagues on the Home Committee, who reported, in March, 1884, that if an entrance were made in the north-east corner, it would be very difficult for vessels to enter or leave the harbour in a cyclone; and he believed that was quite true. They also pointed out that, if a new entrance were formed, there Mr. Dobson.

Fig. 34.

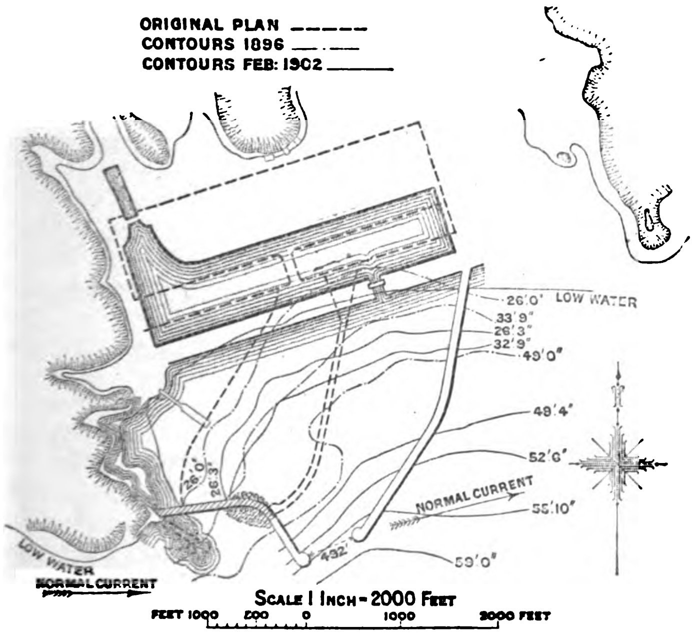


would be two entrances to the harbour for a time, and that in consequence the water would be much more disturbed; and in conclusion they stated that after having carefully considered the question they could not recommend the construction of the new entrance. As had been said by a well-known authority, to make a harbour secure at the expense of its accessibility appeared to be a worse fault than to make it accessible at the expense of its security; because, as a rule, it

Mr. Dobson. was possible to improve the security of a harbour by internal works. For that reason, and bearing in mind that the waves rolled unceasingly towards the shore, Messrs. Hawkshaw and Dobson had proposed in their report of 1901 that a dock should be made at the south-west corner, constructed so as to meet existing requirements, and so laid out that it could be extended as trade developed; believing that even in the heaviest weather such a dock would give security to vessels, which would be able to lie alongside the quay and discharge their cargoes, using the outside harbour as an outer harbour. They considered that it would be very unwise to make an entrance at the north-east corner, necessitating the prolongation of the north-east arm in a northerly direction; and they were of opinion that if that work were carried out it would lead to precisely what the Author showed in *Fig. 16*, namely, silting between the extended arm and the shore. In their report they had suggested that if, when the dock was completed, it were necessary to render the water in the harbour quieter than at present, this could more easily be done by constructing a protecting breakwater, as shown in *Fig. 34*, laid down at an angle of about 30° with the foreshore. At first the intention had been to place it 1,200 feet from the entrance; but after consultation with nautical men, and bearing in mind the necessity of ships being able to enter in the heaviest weather, in a later report to the Madras Railway Company they had placed it 2,400 feet away, and had made it correspondingly longer. To carry out the works suggested by the report of the Commission of 1902 would be to incur heavy expenditure, and to say the least, it was doubtful what the result would be. Bearing in mind Sir Andrew Clarke's statement, that in British India there were more than 2,000 miles of seaboard from Calcutta to Bombay without a single port where vessels could discharge direct on to the quay, he thought it would be agreed that the time had really come for the Government of India to encourage, in some way, the construction by private enterprise—either by new companies or by the existing railway companies—of docks and breakwaters at such a place as Vizagapatam, acknowledged to be the best site on the east coast for a harbour. Otherwise, if the alteration at Madras turned out as he anticipated, the question of harbour-accommodation in India would become still more serious. Dealing generally with the subject of the Paper, the Author clearly showed in *Figs. 3–20* the evils that arose from interfering with the littoral current, or from forming a bay into which the sand might be carried by eddies set up by the works themselves, or by the ground-swell.

Taking all these difficulties into consideration, he thought the great engineers of the past had been right in fixing the entrances to purely artificial harbours at the furthermost points from the shore; and that the solution of the problem lay in the construction of protection-works still further seaward—always assuming that it was absolutely necessary to exclude the ocean swell from the outer harbour, instead of constructing an inner harbour or dock. He desired to bring before the Institution one other remarkable case, that of Salina Cruz harbour on the Mr Dobson.

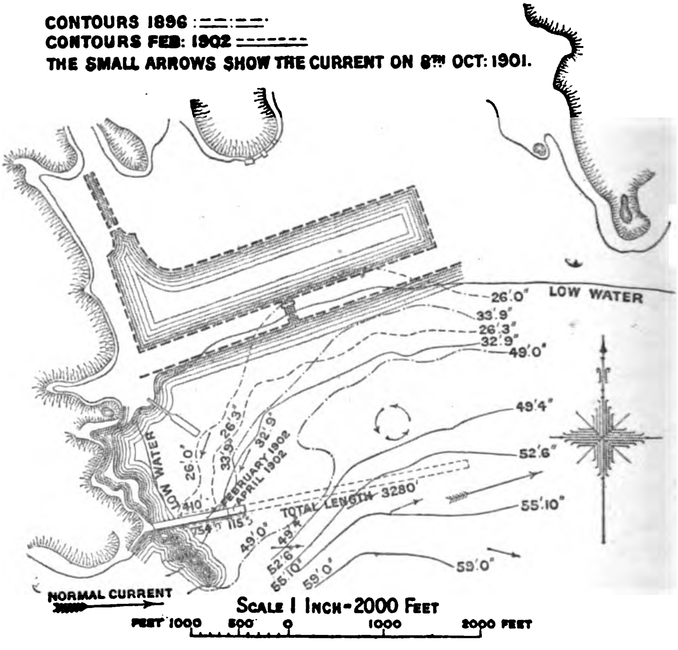
Fig. 35.



Pacific coast, which was being constructed for the Mexican Government by Messrs. S. Pearson & Son. In 1896 Messrs. Pearson requested Messrs. Hawkshaw and Hayter to report upon plans for a proposed harbour at that port, and the result was that a scheme was recommended which was shown by the dotted lines in *Fig. 35.* That scheme included an inner dock and two breakwaters, with an entrance parallel to the flow of the littoral current. The current always ran from west to east, and the wind blew for 4 months of the year from the north, and during the remaining 8 months from the south. The proposed

Mr. Dobson. plan was not entirely approved by the Mexican governmen authorities, who finally decided upon an entirely differen position for the entrance to the harbour, with a breakwate extending from the headland on the west and running in a easterly direction, almost parallel to the dock, as shown i *Fig. 36.* The work was commenced in 1890 according to that plan and the subsequent events had an interesting bearing upon Madra Harbour. As the breakwater was carried out, so the bay whic was protected by it gradually silted up, until in February, 190

Fig. 36.



low-water line immediately behind the breakwater had reache a point where there was originally 26 feet of water. Tl filling-up alone was naturally sufficient to cause anxiety any engineer responsible for the scheme; and yet, no doub it had never been anticipated, because the impression seem to have been that the sand, being coarse, was so heavy th it could not be carried by the littoral current. In Marc and April, 1902, when the breakwater had reached a poi 820 feet from its commencement, the bottom of the bay c the end of the breakwater silted up suddenly to the exte

f 13 feet. Then the Mexican Government decided to revert Mr. Dobson. the plan of 1896, and began to curve the breakwater southward. Unfortunately, the Titan which was on the breakwater t that time was thrown over into the sea, owing to an arthquake-wave, and the whole matter was referred to Messrs. Hawkshaw and Dobson. At first it was difficult to understand the sudden silting up of 13 feet off the end of the breakwater; but on further inquiry it was found that that silting was periodical, and took place quite independently of the breakwater. The winds from the south always brought sand into the bay, and he northerly winds took it all out again. That, in his view, was perfect explanation of the silting, as it was evident the south wind blowing for 8 months considerably lessened the eddy-currents in the bay, so that the sand carried by the strong ittoral current running from west to east would be thrown up nto the slack water east of the headland; whereas the north wind, as proved by actual observations, increased the power and range of the eddy-current, and this carried the sand again into the influence of the littoral current. In order to revert to the scheme proposed in 1896, and to place the entrance beyond the fluctuating conditions existing within the range of the eddy, an awkward bend was given to the breakwater (*Fig. 35*). This was unavoidable under the circumstances; and it was much easier and cheaper to strengthen the breakwater sufficiently at that corner than to begin it over again in a new direction. The rapid shoaling behind the breakwater during its construction was due to the comparatively slack water caused by interference with the eddy-current, and to the absence of any breakwater on the east to exclude the sand carried by that current.

Mr. W. T. DOUGLASS pointed out that in a Note[1] read before Mr. Douglass. Section II. of the Engineering Conference, 1903, he had ventured to express the opinion that, under normal conditions, the travel of the beach was with the flood-tide; while at the same time he did not reject the theory of wave-action, and of the longest fetch bringing in the heaviest waves. The Paper under discussion bore out that theory. *Figs. 12–15, 18* and *19* showed that the beach was growing in all cases on the side of the prevailing wind and the flood-tide. There was no instance of the beach collecting on the ebb-tide side, except in *Fig. 16*, which showed a lee groyne parallel with the shore. Again, at Madras the accretion, occurring entirely on the south side, was due to the flood-tide. He had

[1] Minutes of Proceedings Inst. C.E. Supplement to vol. cliv. p. 46.

Mr. Douglass. examined the majority of the foreshores and beaches of the British Isles, and had found in all instances that the preponderating travel of the beach was with the flood-tide. Accepting this principle, it was possible to decide in a few minutes what would be the ultimate direction of travel of a beach; whereas, if the records of the Meteorological Office as to prevailing winds were studied, it would probably take a month. The silting-up at Ceará was quite in accordance with what would be expected from the conditions shown by the diagrams. There was an isolated breakwater connected to the shore by a viaduct 750 feet in length. As shown by Fig. 21, Plate 4, the viaduct was built over a harbour-reef. The tendency would be for that reef to act as a groyne, and for silting to take place. This condition obtained on nearly every sandy foreshore, where about low-water line there was a small reef, ledge, or island; and in most cases an isthmus of sand joined the reef or island to the foreshore. A notable instance was Portland, where Portland Island formed the isolated breakwater and the Chesil Beach formed the isthmus. The late Sir John Coode, in his Paper on the Chesil Beach, attributed the collection of beach there to the existence of a shelf of Kimmeridge clay standing 4 feet above the foreshore.[1] In regard to Madras Harbour the general effect that would result from the suggested building-out of a breakwater or protecting arm on the north side of the harbour was shown in *Figs. 7* and *16*. A sheltered area would be created on the lee side where the sand would deposit. Another instance was Gorleston, where, about the year 1873, Sir John Coode recommended the construction of a groyne at right angles to the south pier of the harbour, where encroachments had been going on to a very serious extent, which would probably outflank the harbour. The groyne was built of open pile-work, and effectually prevented further denudation of the foreshore. About 1880 this groyne was reconstructed and made solid; with the result that the whole of the foreshore on the south beach was silted up, and the groynes were covered. During the past 12 months the Corporation of Yarmouth had been compelled to raise their sea-wall in order to get rid of the sand trouble. A similar encroachment of the sea on the lee side of the breakwater had been occurring for many years at Lowestoft, and in 1901 he advised the Corporation to construct a groyne on the south face of the southern harbour-pier and at right angles to it. That groyne had now been completed, with the result that the sand had accumulated on both sides of the groyne to a height of 10 feet and the

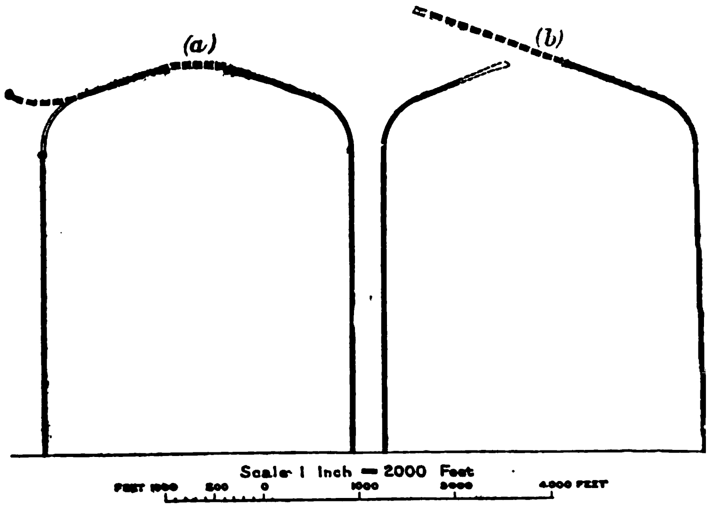
[1] Minutes of Proceedings Inst. C.E., vol. xii. p. 542.

high-water line had already been driven back 150 yards. The groyne was 235 feet in length. His theory of the flood-tide was borne out by every remark in the Paper, with one exception, where he thought the Author, in describing the tide at Littlehampton, was incorrect in stating that there the flood-tide travelled from east to west. It was well known that the flood-tide on the south coast travelled from west to east; though it was true that 2 hours previous to high water the flood-tide at Littlehampton did begin to ebb in-shore and travelled westward for 5 hours, so that there was 7 hours of flood and 5 hours of ebb. With regard to the Author's remarks as to the use of piled structures and their availability for traffic in moderate weather, so far as the landing of goods on the coasts of Great Britain was concerned, there were instances of piers built at Yarmouth, Lowestoft, Southend, Margate, Ramsgate, Brighton, Hastings and Eastbourne, where, even during the summer months, very considerable difficulty was experienced by high-power steamers in landing their passengers; and he thought that if any attempt were made to land cargo from small boats, which were frequently undermanned, great difficulties would arise in taking the cargoes out of the holds of these craft, even with cranes of special design, having long jibs. Further, when these small craft were lightened of their cargoes, they would have great difficulty in clawing off the shore in bad weather. Mr. Douglass.

Sir GUILFORD L. MOLESWORTH, K.C.I.E., Vice-President, remarked that there was one interesting effect of silting which had not been touched upon by the Author, namely, the formation of lagoons. He had seen it often in Ceylon. Where a river debouched at right angles to the foreshore, a sandbank was often formed at one side of the mouth, which was deflected by the flow, parallel to the shore. The sandbank gradually extended parallel to the shore, until a heavier flood-discharge than usual broke through the root end of the bank, and the process was repeated. Some of these lagoons were more than 20 miles in length. With regard to the effect of the movement of water, there were several influences which, combined, often produced different results under apparently almost similar physical conditions. For instance, there was not only the ground-swell, but there were also perhaps monsoon currents, the local current, and the surface waves, acting in different directions. Variations in the relative effects of those elements would produce very different results. As a rule, the ground-swell came broadside on to the foreshore. Having been requested by the Government of India to investigate the causes of the failure of the Madras Sir Guilford Molesworth.

Sir Guilford Molesworth. Harbour, he went there just about the time when the strengt of the monsoon had subsided. There was then a large accu mulation of sand on the north side, which was probably due to th fact that the north breakwater had been commenced before th south breakwater. The accumulation was now on the south sid The report of the Home Committee (Sir John Hawkshaw, S John Coode, and Sir George Gabriel Stokes), recommended th narrowing of the harbour-entrance from 550 feet to 450 feet; bu he had calculated that such a reduction would not make a diffe ence of more than 1 foot in the height of waves inside the harbou 1,500 feet from the entrance. The report of the Madras Committ

Figs. 37.



advised an entrance at the northern elbow in lieu of the existi entrance at the east front, and on this point he had report thus:—

"The 'Madras Committee,' however, has recommended the closing of present entrance, and opening of a new entrance in the north elbow, this entra being covered by a projecting break-water curving out from the eastern tange this elbow. The entrance to a harbour at right angles to the general directic the swell is generally considered to be a very disadvantageous arrangement ; when a vessel is entering such a harbour, half protected by the entrance, and exposed to the action of a heavy wave, it is liable to be swung round, and strike

[1] "Papers connected with the Construction of the Madras Harbour," pp. and 174.

ntrance before it can recover itself: this is a contingency to which modern vessels from their extreme length are especially liable. . . . Assuming, however, the feasibility of such an entrance, I am of opinion that the form of break-water proposed for covering this entrance requires some modification. In its proposed form it is open to serious objections, involving, as it does, a re-entering curve. . . The meeting of the confluent waves along the face with those rolling in direct from the sea would set up a very severe action, and the blows on the concave surface would be so severe that nothing in the shape of a break-water could withstand it. . . There is another alternative entrance that might be worthy of consideration as offering shelter to the harbour without the objectionable features of either of the foregoing alternatives. This is shown in . . . [*Fig. 37b*], one of the faces being extended so as to cover the existing entrance, and, by demolishing part of the other face, a sufficient width for a free entrance may be obtained. This would allow an entrance in deep water, and it is doubtful whether it would be more expensive than the plan proposed by the Madras Committee. If there should be a tendency to rapid shoaling to the south, it might be desirable to extend the other face so as to give the entrance to the north instead of to the south; but in this case the extension would have to be rather longer, to give an equal cover to the entrance." Sir Guilford Molesworth.

The entrance proposed by the Madras Committee was shown in *Fig. 37* (*a*) and the modification proposed by him in *Fig. 37* (*b*).

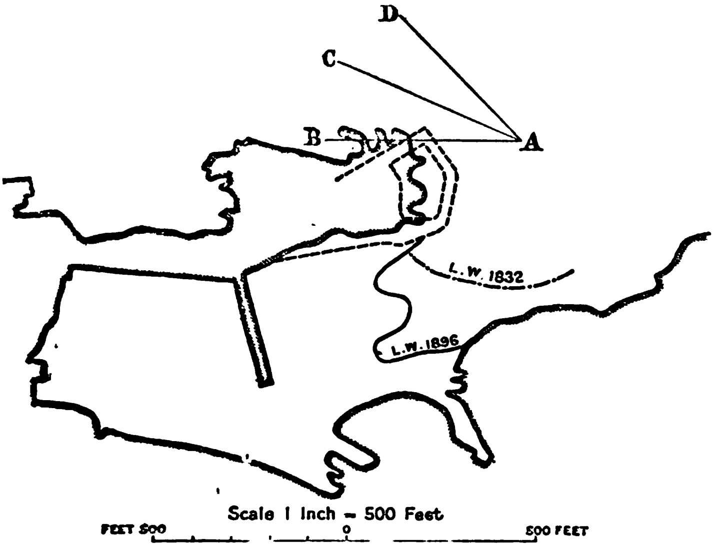
Mr. WOODFORD PILKINGTON mentioned that he had had a good deal to do with the Ceará harbour-works, having been appointed resident engineer on them in 1885. On arriving at Ceará he had checked the soundings previously made by the staff of Sir John Hawkshaw, and had found them to tally in a remarkable way; showing that there had been absolutely no change in the bottom during the 10 years. He had then pointed out to the contractors that it would be possible to improve on the breakwater, and to prevent the harbour from becoming a land-reclamation scheme instead of a harbour, by turning the breakwater-arm outward in the direction of the wind and wave, instead of turning it into the shore and stopping the current. He had contended that if that alteration were made a thorough scour should be produced throughout the harbour, and silting would be stopped. He had been told, however, by the agent of the contractors, that if the alteration were made no order would be given to proceed with the works for another 3 months, and the contractors would lose their concession; he had therefore given in, though he had been persuaded the place would be silted up. The work accordingly proceeded, and shortly afterwards he relinquished all connection with the works. The cause of the failure of the works was that the breakwater's inner end was curved in towards the shore, thus deflecting the waves caused by the north-east monsoon, and so stopping the inshore equatorial current. It should have been curved out so as to be parallel with the foreshore. Only one-half of the curved Mr. Pilkington

Mr. Pilkington. viaduct was open piling, 350 feet at the inner end of the breakwater being formed of solid concrete; this should have been open viaduct, like the rest. As it was, it formed a deflecting cushion on which the waves impinged and drove inshore. It should have been turned the other way, so as to guide the waves along the outer side of the breakwater; then instead of contracting the channel-way, it would have increased the force of the scour of the wave, acting with instead of against, the equatorial current. He had also brought these views to the notice of the Chairman of the Company before the works had advanced so far as to make it difficult to alter them, but without effect. Sir John Hawkshaw was not to be blamed for the failure of the works, as he had never been consulted as to their execution; but the authority of his great name had prevented timely alterations from taking place when needed.

Mr. Moore. Mr. R. St. George Moore regretted that more had not been heard about home harbours. For instance, he would have liked to hear a little about Portsmouth Harbour, because there was a great deal of interesting information to be obtained from it: moreover, it was near home, and most of the members had had an opportunity of actually seeing it. He had recently been told by the late Superintending Engineer of Portsmouth Dockyard that, in his opinion, the scour had been so successful that it was hoped it would soon be possible to widen the mouth of the harbour. The harbour of Ilfracombe afforded an interesting illustration of the effect of wind and waves in producing scour. In *Fig. 38* the line A B lay east and west, C A was the line of the longest fetch outside the harbour, and D A was the line of the most prevalent of the winds entering the harbour. That wind blew for about 21 days per annum. The dotted lines showed some new work, carried out in 1880, partly solid and partly open. The result of that work was a change in the low-water line of spring tides, between 1832 and 1896, as shown in *Fig. 38*. There was a stream coming out of a culvert, on the south side of the harbour, and passing down the harbour; but it was so small that it would have no effect whatever on the scour. The whole of the scour must therefore have been due to combined wave and wind action. On examining the harbour about 1895, the first point he had had to investigate was why the scour had stopped at that point, and he had found that rock underlay the surface only a few inches. He had then been authorized to dredge away all the rock, so as to see whether further scouring would take place. The works were [co]mplete in 1900, and he expected in the coming summer to

make a further survey. Christchurch Harbour (*Fig. 39*) was a natural harbour, in that no works had been ever carried out there. In 1662 a Mr. Yallender proposed to canalize the rivers Stour and Avon, using Christchurch Harbour, which was large and land-locked, for the purpose. The peculiarity of the harbour was that in 1811 there was a short direct entrance, whereas by 1870 a spit of land had extended parallel to the shore, diverting the entrance about 1 mile to leeward. By 1896 the spit had diminished as shown in *Fig. 39*: and at present it was extending again. There was a large volume of fresh water coming down the harbour. He had had occasion to gauge the River Avon, and in ordinary winter Mr. Moore.

Fig. 38.



ILFRACOMBE HARBOUR.

weather the flow was 300 to 400 million gallons in 24 hours; while the River Stour had quite an equal amount. If extended, *Fig. 39* would follow somewhat the lines of *Fig. 16* in the paper, the breakwater being represented by some sunken rocks which diverted the current. The erosion of Hengistbury Head had been about 800 feet since 1840. He would also like to endorse the Author's view that in many instances a piled structure would supply all reasonable trade facilities; as he was of opinion that the utility of properly-designed open piers was much under-estimated. The direction and force of the wind might be

The Author. The AUTHOR, in reply, expressed his thanks for the reception accorded to his Paper. The discussion he thought had in almost every instance emphasized the points he had endeavoured to bring out. In contrasting Yarmouth and Lowestoft, Mr. Matthews had not mentioned the depths at low water at the mouths of those harbours, which it would be valuable to know. The additional information Mr. Matthews and Mr. Thorowgood had given as to Madras, bringing its history up to date, was very interesting. His main contention as to Madras was generally supported by these more recent records. In a Paper[1] by the late Mr. Horace Bell, M. Inst. C.E., entitled "Notes on the Ports and Harbours of Peninsular India," the following reference was made to the Port of Madras:—

> "The history of Madras, as a port of any importance, dates no further back than to the days when we selected the place as a trading settlement, and built Fort St. George, in 1639. It was then—and it is scarcely better now—an open roadstead, liable to be swept by storms or hurricanes of intense violence, when every vessel that could venture on the process had to go to sea for safety and a good offing, as indeed is the case at the present day."

The nautical evidence was to the effect that the only gales at Madras were cyclones; and according to the statement of the harbour-master, in cyclones ships had to be sent to sea for safety. In other words, it looked as if in ordinary weather the harbour was not required, while in cyclones it could not be used. He had not visited Madras, and therefore he spoke with great deference; but that was what the observations seemed to imply. Over £500,000 had been expended on the work at Madras, to say nothing of the loss due to the injury to the coast-line by erosion on the lee side. His point with regard to Madras was that the circumstances would have justified a pile-work rather than a solid structure. A piled pier would doubtless have been to some extent intermittent in use; but in the light of the evidence available, it certainly seemed that such a structure would have provided the required facilities. He agreed with Mr. Case that the slope assumed by a beach under different conditions of the wind was largely dependent upon the size and weight of the components of that beach. His remarks had reference to a foreshore with shingle leaving, say, 20 per cent. to 25 per cent. on a $\frac{3}{4}$-inch mesh. With a ground-swell, or a dead-on sea, the shingle was tossed up on to the crest, and the toe of the slope was raked

[1] Journal of the Society of Arts, vol. li., p. 702.

out. As the wave-action increased or slackened, the result was nearly always a series of terraces. A similar result was produced by the variation of the levels of high water, when what might be termed "tidal terracing" resulted. The steeper slope of Dungeness ran a little south of east and north of west, so that the prevailing and heaviest seas struck it almost broadside on. Here the shingle lay at a slope of 2 to 1 in deep water, with a shelf of mud at the foot of the slope. In the late Sir John Coode's Paper on the Chesil Bank was shown [1] a section taken after the storm of the 27th December, 1852. The sea was then practically dead-on, and the slope was cut out so that the profile of the bank was almost exactly parabolic. With regard to Mr. Case's question as to *Fig. 8*, in the centre of the foreshore, between the piers, the forces causing the shingle to oscillate would be checked by reason of the solid portions of the two break-waters. On the flood, for instance, there would be a dead centre where the tidal impulse was checked, owing to slack water. At the same time a reflex action would be set up by the tidal force striking the leeward breakwater. As the forces of flood and ebb were assumed to be equal and opposite, the result would be a thickening of the foreshore in the centre between the breakwaters. The instance of the sanding-up of a solid pier on the Nicaraguan coast cited by Mr. Hunter was most interesting. Mr. Hunter was perhaps a little hypercritical as to the phrasing of the opening sentence of the Paper. It might have been better to substitute for the words "the balance of the littoral forces," the words "the littoral regime." The Author's point was this:—Given a length of coast under conditions substantially stable, there was a balance of littoral forces, and at the same time constant movement. Equilibrium of condition and movement of coastal drift both existed, because month after month the regime of the coast was normal. If an obstruction, such as a groyne or solid pier, was built, immediately the balance was upset and new conditions were created. The action described by Mr. Inglis in his remarks as to Teignmouth was going on at the entrance of every exposed river-outfall and estuary. On the Sussex coast the River Adur ran approximately north and south, but on reaching the coast-line it took a sharp twist to the east before debouching into the sea. The outlet was driven to leeward, as described by Mr. Inglis. In the same way the River Ouse formerly discharged under Seaford Head, 2½ miles east of the present largely artificial outlet. The same action might be watched going on in the neighbouring River Cuckmare. The Author.

[1] Minutes of Proceedings Inst. C.E., vol. xii. Plate 2.

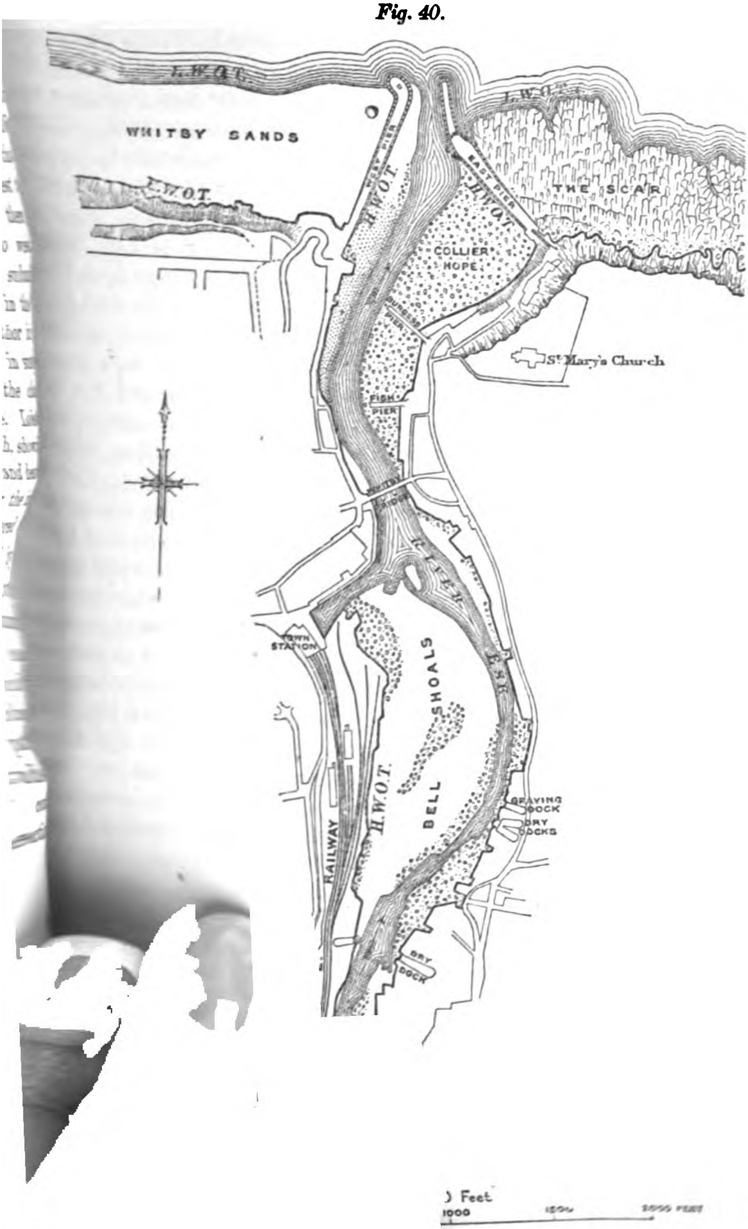
The Author. The river there was continually being driven eastward, until some extraordinary freshet burst a new channel to the sea, when the same cycle recommenced. Similarly, the River Blyth, which flowed out at Southwold, formerly had its outfall at Dunwich, 3 miles to the south. With regard to Mr. Douglass's remarks as to Littlehampton, it was well known that in the English Channel the normal drift was from west to east; but Littlehampton was one of the places where there was a false or counter flood-tide running from east to west. The Author's remarks as to Littlehampton had been submitted to the harbour-master there before being inserted in the Paper. Dr. Owens rather took the same view as the Author in regard to sand-travel. The fine particles were floating in suspension, as could be seen on any coast by reason of the change of colour when the tide ran strongly on a sandy shore. Lobster-pots were sometimes filled with sand at 30 fathoms depth, showing that the erosive action went on in deep water. Coarse and heavy sand travelled along the sea-bottom much as it did under the influence of a high wind on shore. On penetrating a sheltered area it rapidly dropped to the bottom. The scour produced by eddies, referred to by Dr. Owens, was utilized in some places to produce a slight deepening over a shallow bar. If a barge were grounded on the shallow spot as the tide was ebbing, the obstruction caused a gap to be dug out by the force of the effluent current, which might lower the bar a foot or two at the worst place. In conclusion, he echoed the remark made by Mr. Matthews as to the particular features of each locality requiring to be specially studied. As he had said before, it was that infinite variety of conditions which constituted one of the greatest charms in connection with sea-works.

Correspondence.

Mr. Austen. Mr. H. C. M. AUSTEN thought that, as an illustration of th Author's second type of harbour—at the mouth of a river—an of the value of tidal scour as a means of maintaining a clea entrance, the case of Whitby Harbour (*Fig. 40*) might be of con siderable interest. Steps had been taken in 1845 to remove the ba which had formed at the entrance of the harbour between the pier

Mr. Austen.

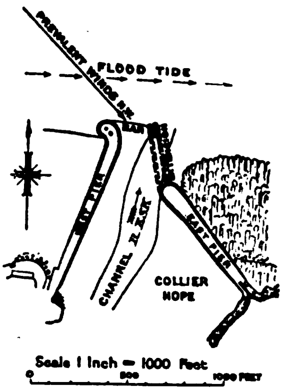
Fig. 40.



WHITBY HARBOUR.

Mr. Austen. heads, as shown in *Fig. 41*. This bar, as would be seen from the plan, was formed by the meeting of the flood-tide, charged with sand, and the flow through the river-channel. The result of the meeting of those two currents was to form an eddy just inside the end of the west pier-head, and consequently slack water. This caused the sand, with which the water was heavily charged, to be deposited, and in time the deposit had taken up the position shown. Thus a vessel desirous of entering the harbour had had to go nearer the east pier in order to avoid the bar; in so doing, it had been in danger of losing steerage-way owing to the strength of the flood-tide (which flowed eastward at a considerable rate), and had tended to drift beyond the east pier-head before making the entrance. In order to minimize the trouble of the bar, some large stones had been placed NNW. of the west pier-head, below the water-level at which ships might safely enter the harbour. These stones had acted as a groyne, tending to prevent the formation of the bar by arresting the eastward progress of the sand-deposit. The remedy which had been adopted was shown in full lines in *Fig. 40*, and in dotted lines in *Fig. 41*, the object having been to bring the pier-heads both in a line parallel to the set of the tide. This had reduced the width between the pier-heads by nearly one-half, had removed the bar, and at the same time had reduced the heavy seas which formerly entered the harbour and expended their force within it. The projection of the east pier, however, caught the heavy seas from the north-west, instead of allowing them to pass. The waves, passing over shallow water, stirred up the sand, with which they became heavily charged, and swept along until they struck the inner face of the east pier extension, off which they rebounded within the harbour, where, on reaching slack water, the sand was deposited. Besides silting up the harbour, the decreased width of the mouth had made the entrance exceedingly dangerous, as, owing to the rapid cross flow of the tide, a vessel had great difficulty in shooting between the pier-heads when running before a north-west wind. She might strike the east pier-end or drift on to the rocks beyond; or, if she effected an entrance, she might collide with the

Fig. 41.



inner face of the extension. The west pier, and the old east pier before the formation of the bar, had been admirably constructed, so that a vessel might enter the harbour under the lee of the west pier, and yet, from the width of the entrance, do so without fear of losing too much steerage-way. It had been proposed by the late Mr. James Abernethy, Past-President Inst. C.E., that, after demolishing the extended arm and rebuilding the old pier-head, the harbour should be kept clear by tidal scour; in other words, by converting the inner harbour above the bridge into a tidal reservoir. He had proposed to dredge as large an area as possible between high- and low-water lines above bridge by removing the Bell shoals, and thus to increase enormously the tidal capacity of the harbour; so that the large volume of water passing in and out at every tide would have a powerful scouring action, which would maintain the channel at a fixed depth and would keep the entrance clear by removing the bar. In Mr. Abernethy's opinion, the natural shape of Whitby Harbour, which might almost be compared to an elongated bottle, was admirably adapted to the purpose; and he had considered that the alternative of converting the area above the bridge into a sluicing-basin would be valueless, where the length of channel to be scoured was so great: thus bearing out the Author's observations as to the local effect of artificial scour. Mr. Austen.

Mr. Ernest Benedict observed that many years ago the late Mr. Charles Richardson, M. Inst. C.E., the Engineer of the Severn Tunnel, who lived the greater part of his life on the Wye, the Avon and the Severn, wrote a paper [1] on "Tidal Scour in Rivers," in which he affirmed that the volume of fresh water determined the size of the estuary, and that the tidal waters had nothing to do with it. The natural conclusion was that, where there was no freshwater flow, the estuary would tend to fill. Was not, therefore, the absence of any freshwater flow the main cause of the difficulty in keeping open the Madras roadstead? It had been truly observed that any backwater to a tidal harbour should on no account be curtailed. Now the backwater at Karachi, as the plans accompanying some of the Papers[2] read before the Institution clearly showed, had been seriously curtailed; first by damming the Chinna Creek; secondly, by narrowing the opening in the Napier mole; and thirdly, by not providing an inlet at or about high-water, and an outlet at or about low water, both at the mouth of the Chinna Creek, and away to the west, where only a narrow strip separated Mr. Benedict.

[1] A copy of this Paper is in the Library of the Institution.

[2] Minutes of Proceedings Inst. C.E., vol. xxiii. p. 457, and vol. xliii. p. 1.

Mr. Benedict. the backwater from the sea. In fact, had it not been for the Layari River, there could be no doubt that the trouble due to silting in Karachi Harbour would have been enormously increased.

Mr. Bent. Mr. BALDWIN H. BENT pointed out that the chief natural conditions which affected the site at Ceará were:—(1) The great equatorial current, which struck the Brazilian coast at Cape São Roque, where it divided into two streams, one going south, the other north-west along the coast past Ceará, running about $\frac{3}{8}$ knot per hour on flood-tides, and $\frac{3}{10}$ knot on ebb-tides. (2) Great sand dunes, practically bare of vegetation and about 200 feet high, along the whole coast-line of 600 miles from Cape São Roque to Maranhão (Ceará lying between these places and 230 miles north-west of São Roque). (3) A prevailing wind from the east. Also, the coast-line for 3 miles on each side of Ceará ran almost due east and west. The larger ocean-going steamers anchored 2 to 3 miles off the town, while smaller ships and all coasting vessels lay between the Coröa Grande, or Great Reef, and the shore. The average level of this reef was about 10 feet below low water of spring-tides. As the Author had alluded to Ceará Harbour as one of the most remarkable instances of silting within his experience, the following brief history of the circumstances might be of interest. In 1874 Sir John Hawkshaw was called in by the Government to report on all the Brazilian ports, among them Ceará. Sir John no doubt noticed the natural conditions mentioned above; also that the current confined between the Great Reef and the shore was sufficient to keep clear a useful roadstead for coasting vessels. He therefore recommended that a solid breakwater should be built, more or less parallel to the shore, and connected with it by an iron viaduct 750 feet long; the breakwater itself to be 2,200 feet long (of which 1,400 feet were actually constructed). The current was to pass through the open viaduct, carry the sand along with it through the still water behind the solid breakwater and out the other side, the same as happened behind the Great Reef. There was, however, one vital difference between the breakwater and the Great Reef. The top of the breakwater was 16 feet above, while the average level of the top of the Great Reef was 10 feet below, low water of spring-tides; so that in the latter case the waves were always stirring up the water and the sand in it behind the reef. So long as the waves did this, the current was able to keep the sand moving; but when the sand came through the viaduct into the sheltered area behind the breakwater, where the waves could not act on it, it simply subsided, the current being too weak to hold it up and

keep it moving at the same time. Thus the proposed deep-water harbour became a sandbank. Another thing, in the beginning, also tended to the silting, namely, there were too many piles in the viaduct; there were four rows of them, 8 feet 9 inches apart, with 30-foot spans. He had been told that as these piles were put down a tongue of sand followed them out from the shore, closing in a measure the opening that should have been 750 feet. The silting begun in this way was completed by the solid structure of the breakwater, and, sometime before work on it was stopped, the passage through the viaduct was completely closed; the sand then began to come round the end of the breakwater into the sheltered harbour. This sand did not join up to the other bank which had come through the viaduct, so that there remained a pool of water behind the breakwater, between two banks of sand. Another effect of the breakwater—a serious one at the time—was that it acted as a great groyne running out from the shore; with the result that erosion took place to leeward to such an extent that the gasworks, originally some 200 yards from the foreshore, were in danger of being carried away, and were only saved by tipping rock along the front of them. This was the position of things in 1889, when Sir George B. Bruce, Past-President Inst. C.E., was called in to arbitrate between the Harbour Corporation's engineers and the contractors. It should perhaps be stated that, beyond the original design of the harbour, which they made for the Brazilian Government, Sir John Hawkshaw's firm had nothing to do with the works. In arriving at his decision, Sir George obtained such a knowledge of the circumstances and conditions of the place that the Corporation asked if his firm would become their consulting engineers, and advise them what should be done to make the best of a bad job. Messrs. Sir George Bruce and White thereupon sent an engineer to Ceará. On arriving there this gentleman saw the danger the gasworks were in, owing to the erosion of the coast to leeward of the harbour-works, and argued, Mr. Bent imagined not unreasonably, that as the construction of these works had caused this erosion, the proper thing to do was to build a big groyne from the shore to the east, in such a position that the erosion caused by it on its leeward side should clear away the sand that had accumulated about the viaduct; and this, helped by some dredging, would clear the harbour, and make it what it was originally intended to be. Many soundings and current-observations were taken to decide on the best position and direction for

Mr. Bent.

Mr. Bent. the groyne, and this plan was finally adopted in 1891. Owing to the naval revolt in Brazil, it was not until the beginning of 1894 that a start was made on the work. At that date a powerful suction-dredger, was sent out, and was shortly followed by Mr. J. L. Houston, M. Inst. C.E., for Messrs. Punchard, McTaggart, & Co., Lowther, the contractors, and by Mr. Bent, who was resident engineer for Messrs. Sir George Bruce and White. On arriving at Ceará it was seen that the condition of things had considerably altered from what it had been reported to be 3 years before, especially about the gasworks, to leeward of the breakwater. Where the sea had then been breaking against the gasworks wall, there was a sandy beach 150 yards wide between the foreshore and the wall; in other words, the erosion caused by the breakwater was only temporary. With these additional 3 years it was easy enough to account for what had happened. The sand-laden water, travelling always in one direction along the coast, became charged with sand in two ways, namely, the sand was blown into the water by the wind, or it was taken up by the waves breaking on the sandy shore. It was important to notice, however, that the general coast-line was not much affected by this latter action, because, although sand might be taken from a particular spot by the waves and current, the same agency replaced it by a supply from the east. If, by any chance, this supply should be cut off, then the shore would be eaten away, and this was what had happened to leeward of the breakwater. For some years the sand travelling west was being used for the greater part in filling the quiet area behind the breakwater, and very little went past the works; yet all this time the waves continued breaking on the shore to leeward of the breakwater, and so eating it away, till finally, as already stated, they attacked the gasworks. Then at last, when the area behind the breakwater became filled, the supply once more began to go on past it, the artificial hole to the leeward of the breakwater began to fill, and the line of the foreshore advanced seaward to its natural position some 150 yards from the gasworks. Seeing all this, he could not but feel convinced that if the proposed groyne were built, much the same thing would happen again. The groyne would arrest the sand from the east for a time, and there would be considerable erosion to leeward of it, which would perhaps clear the viaduct; but this action would be only temporary, until the angle on the east side of the groyne was filled, when the sand would once more pour round the end and fill again the area by the viaduct: indeed, this seemed far more likely to happen here than at the gasworks, because the groyne would have the

breakwater and viaduct standing out from the shore to the west of it and acting as a second groyne, whereas to the west of the breakwater the coast-line was quite unbroken. Having regard to all this, and also to the fact that there were about 1 million cubic yards more in the harbour area to be dredged than had been estimated, the engineers decided to abandon the groyne scheme, and substituted a properly fitted basin, with a narrow entrance, to be dredged behind the breakwater, making use of the pool already referred to. There was no special difficulty about this, and the scheme was gone on with. The Brazilian Government, however, who behaved very fairly throughout, were, not unreasonably, much disappointed at the idea of so small a port after the original design, and refused to sanction the plans, although their engineers were unable to propose anything more feasible. The Corporation therefore suggested that the Government should purchase the works, and this, after the passing of an Act of Congress, and many weary months of bargaining and valuing, was finally done, and the work was abandoned. The moral of the failure would seem to be, that it was not practicable to make a successful quiet harbour on such a coast, unless there was sufficient traffic to pay for the necessary dredging. Where such an amount of sand was in suspension in the water, ½-knot currents might carry it along, so long as waves could shake it about; but so soon as it came into a sufficiently sheltered area, *e.g.*, behind a long breakwater, the sand would at once fall down, and, without dredging, the sheltered area would naturally become useless as a harbour. Under these circumstances it would seem best to construct only a low breakwater, say up to low water of extraordinary spring-tides, parallel to the direction of the current, but in no way connected with the shore; as an adjunct a jetty with good wide spans might be built out from the shore, behind the shelter of the breakwater. With only 8½ feet range of tide, such a breakwater would make a useful shelter, though he admitted it would not be a perfect harbour. Mr. Bent.

Mr. W. DYCE CAY considered that the groyne system adopted in many parts of the south coast of England was admirably adapted to the sites and the shingle beaches. With suitable modifications it might be useful for protecting the foreshores of breakwaters constructed with rubble foundations; or breakwaters might even sometimes be constructed of large rubble, with a system of transverse groynes dividing their exterior length into a succession of bays, in which the rubble might be worn by the waves but not moved away shoreward. In designing harbours, Mr. Cay.

Mr. Cay. people were often induced to believe that the effects, as to scour and maintenance of depth, produced by ebbing currents or by sluicing-basins when the harbour channel was shallow or even bare at low water, would be continued when a depth of, say, 2 to 4 fathoms at low water had been attained. This, however, was frequently not the case, as then the ebb-current, especially if it contained the fresh water of a river, flowed clear of the bottom owing to its lower specific gravity; and thus for an illusory advantage, the benefit to the navigation of width of sea-way was often sacrificed. In most cases he had been connected with, a harbour enclosed by breakwaters with their shore ends formed of open viaducts (*Figs. 8* and *17*) would not have been successful, as the sand-laden water would have passed inside, through the viaduct-openings, and would there have discharged itself, when no longer agitated by the waves. The great improvements in dredging-appliances in the last 30 or 40 years placed the maintenance and improvement of harbours liable to sanding on a much simpler basis than previously. A piled breakwater had been built at Blyth nearly half a century ago, and had been described[1] by Mr. Michael Scott in the "Proceedings." It had consisted of a creosoted pine casing filled with rubble. When Mr. Cay visited the work in 1867 some damage had occurred from the sea-worm (*Limnoria terebrans*), especially at the ends and fastenings of half-timbers; also the basket-work head was much broken, as if a ship had struck it. It stood on a reef which extended several hundred yards seaward of it, and was protected for a considerable part of its length by an old breakwater lying about 200 feet seaward. He noted that in 5 or 6 years very extensive repairs would be required by the lower timbers. It had since been replaced by a concrete structure.

Mr. Mann. Mr. I. J. MANN remarked that the movement of sand on the foreshore, and on the sea-bottom immediately adjoining the foreshore, had been the source of much trouble and expense in the construction and maintenance of many, if not the majority, of harbours; and this fact was well exemplified by the various cases to which the Author referred. Underlying the question of sand-movement was one about which very conflicting statements had been made, namely, the depth to which the disturbing action of a wave extended. There could be little or no doubt that this depth was proportional to the height of the wave measured from hollow to crest, and if this proportion were ascertained by a well-

[1] Minutes of Proceedings Inst. C.E., vol. xviii. p. 72, and vol. xix. p. 644.

ranged series of observations, it would form an item of informa- Mr. Mann.
on that would be extremely useful, and would do much to
revent the recurrence of disastrous failures, which were no
oubt due to an imperfect knowledge of the laws that governed
e movement of sand by the sea. With regard to the sugges-
on made by the Author as to the substitution of piled
ructures for those of solid masonry, no doubt the former could
carried out to deep water much more cheaply and quickly
an the latter. There was, however, the formidable objection
at the piled structure provided no shelter whatever for vessels
ing alongside it, and could not be used with safety in rough
eather. On the other hand, if the movements of the sand on a fore-
ore were previously ascertained and understood, a harbour could
many cases be so designed as to provide at moderate cost both
elter and deep water, without interfering with the natural effects
waves and currents on the bottom in shallow water; and thus
e danger of shoaling could be avoided.

Mr. A. WHARTON METCALFE observed that the Author had cited Mr. Metcalfe.
Figs. 3–20 a possible series of interesting though troublesome
ses, all probably correctly diagnosed, but for which, except in
few instances and in the conclusion of the Paper, he had not put
rward any remedy. The problems met with in practice had a
nack of eluding a list of typical cases. Any given case might
semble a typical one, but would differ in some important and
equently obscure particulars, which showed the futility of
ealing with it on general lines; and the Paper furnished proof
f the necessity of thorough and scientific methods of obtaining
he data on which designs or remedial measures should be based.
hese data were evidently—

(1) The amount and nature of the sea-borne sand or other
aterial held in suspension by the sea-water entering and sur-
ounding the harbour, and the amount which might enter the
arbour from land water.

(2) The amount of wind-borne sand which might be deposited
n the harbour from land in its immediate vicinity. In some
arts of the world, notably South Africa and South America, this
night be considerable, and become the dominating factor.

(3) The velocity of tidal waters outside and entering the
arbour, or of fresh water entering.

(4) The direction and nature of such tidal currents.

(5) The shape of the foreshore and the material on it subject
o tidal influence.

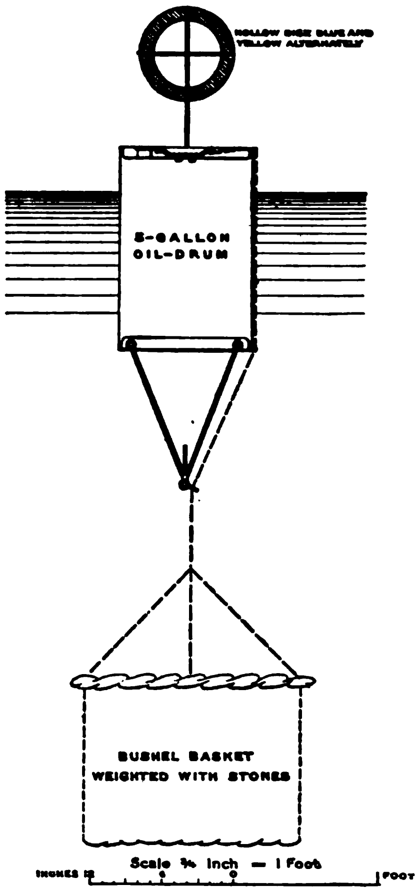
Complete information on these points would obviate much of the

Mr. Metcalfe. uncertainty which seemed to have surrounded the design of ma tidal harbours on sandy coasts. In order to obtain the inforn tion, investigations must be undertaken on systematic and scienti lines, and on an adequate scale; and such investigations were nec sarily costly and added to the preliminary expenses of a schen In large schemes such as the new Avonmouth dock or the docki tion of the Avon previously proposed, the cost of the investi tions was not felt. In small schemes such investigations w equally essential, even though their cost formed an apprecial item in the total expenditure; because they enabled the engin to say with reasonable certainty whether a proposed scheme shou be proceeded with or abandoned, and, if proceeded with, wl modifications or additions should be made. Taking the seve data seriatim, the accumulation of sand might be ascertained measuring the deposits in fixed areas of suitable size, enclosed planks spiked to uprights and having a level plank floor spiked short posts driven down, or in sunken tanks. These enclosu would be placed at various points between high and low wat and the measured deposits, taken in conjunction with curre velocity observations, should furnish the required informati Where mud and sand were in suspension, or in a muddy ri entering a harbour or roadstead, these data might be supplement by taking samples of water in open-ended tubes of uniform bo 4 to 5 feet long, attached to battens for the purpose of imm sion vertically, the openings being closed by corks when tube was full. Samples taken thus at various points along river, at the same phases of the flood and ebb of spring and ne tides, had furnished the data for the dredging-estimates, etc., connection with a joint report by Sir John Wolfe Barry, Benjamin Baker and Mr. A. C. Hurtzig, on the question of dockization of the Avon, upon which their opinion was sought the Docks Committee of the Bristol Town Council in 1899. T amount of wind-borne sand might be estimated in the case o new proposal by means of shallow rectangular flats anchored different points along the shore, over the site of the propo works, or mounted on posts above high-water level; in case of harbours which were sanding up, it would be checked deducting from the accumulated deposit over a certain period amount estimated to have been brought in by the agency of ti and upland water. Such observations should afford fairly relia data. The velocity and direction of the tidal and river curre affecting any particular case were obtained by one operation, a three methods might be adopted: (*a*) a boat might be float

wn-stream, and angular observations with a sextant be taken three or more natural objects on shore, the time being taken by watch: (b) a boat might be floated on the current, its course being oked by one of the occupants, and the time it took to pass cerin transit-stations on shore at known distances apart being taken watch. Method (a) was unsuitable for accurate work, especially a rapid tideway and in any but the most favourable conditions weather and wind. Method (b) was cumbersome, requiring too any boats for exhaustive observations, especially where time was ort; also, the transit-stations must be fixed with some regard to nvenience of measurement from each other, and might require evious careful surveying and setting out. The third method had en proposed by Sir John Wolfe Barry in connection with his report the Bristol docks in January, 1896, for the purposes of which number of observations of the tidal currents in King Road, at e mouth of the Severn, had been required. Briefly described, e method was the following:—A number of convenient theolite-stations were fixed along the shore, their position being fficiently accurately determined by a number of angular observaons from each to known objects. A steam-tug anchored in a lected position beyond the highest or lowest station—according it was flood or ebb—served as a point of departure from which number of buoys were started at a given signal, and at prearranged intervals. Each buoy consisted of a 5-gallon oil-drum nk to a sufficient depth to reduce windage, and kept upright a bushel basket of stones attached to one end of a rope ssed through a shackle at the end of an inverted tripod on e under side of the buoy, its other end being fastened to a eat on the upper side of the drum, to allow of the depth of the nker being varied. The filling-hole in the top of the buoy was osed by a wooden plug, into which was inserted a distinguishing loured flag or semaphore, such as a painted metal disk or cross Fig. 42). When started, the buoys were observed by the assistnts at the theodolite-stations, and observations were taken at greed intervals from the moment of starting, the angles being aken from the most convenient base in each case. A rowingoat accompanied the buoy at some distance, to afford the obervers some indication as to where to look for and follow the uoy when the water was choppy. One of the assistants accomanied the boat, and when by his watch—all observers' watches were synchronized at the beginning of the day—it was time o take an observation, a flag on a long pole was held up for 5 seconds, during which time the buoy was to be observed. Mr. Metcalfe.

Mr. Metcalfe. When plotted, the results on the whole were found to be good, though towards the end of the day, when watches began to differ, they were less satisfactory, and the intersections in a few cases were not as numerous and as clean as could be wished; further, the 15 seconds during which the boat-flag was held up in order that observations might be taken was too long a time, and affected some of the results, as did also the increasing length of time it took the starting-signal from the tug's syren to reach successive theodolite-stations. In order to avoid these sources of error, as was particularly desirable in a fast tideway, he had suggested to his friend, the late Mr. J. M. McCurrich, the Engineer to the Bristol Docks, that marine chronometers should be substituted for watches, and that the observations at the start and throughout should be made at the instant the boat-flag came to the vertical, which instant was made to coincide with the pre-arranged times of observation. The results when this was done left nothing to be desired, and subsequently chronometers had always been used for similar work by Mr. McCurrich, and by his successor Mr. W. W. Squire. The form of the tidal currents, especially of inshore eddies, was greatly affected by the configuration of the coast-line, but it was unnecessary to enlarge upon this point, because, if a sufficient number of current-observations were taken on the lines described, that influence would become clearly apparent in the shape of the stream-lines, even to the extent sometimes of forming loops and figures of 8 if taken near the turn of

Fig. 42.



he tide. With regard to the nature of the material of the foreshore ed, when it was remembered how slight a current began to 'ear away the bottom, and that its erosive power, increasing robably with the depth, increased also with, but at a greater ate than, the velocity, as did also its capacity for holding aterial in suspension, it would be conceded that a case had een made out for instituting exhaustive preliminary observations f the kind described, in all cases where there was uncertainty. 'here were few branches of engineering in which the necessity r such observations was more emphatic than in marine and iver engineering, particularly that portion of it which dealt with idal harbours on sandy coasts. Mr. Metcalfe.

Mr. H. B. Molesworth observed, in reference to the want of arbours on the coast of India, that the possibility of making good harbour at Vizagapatam had frequently been pointed ut. The principal British naval base in the East Indies was t Trincomalee on the north-east coast of Ceylon, which was natural harbour, but was without railway communication, ocks, repairing facilities, or trade of any sort. On the whole ast coast of India, south of Calcutta, a length of about 1,400 iles, there was not a single port where a ship could take helter, go alongside a wharf, or be docked or repaired. This oast was periodically visited by cyclones and exposed to the monsoon. He was well acquainted with Vizagapatam, and was of pinion that it was eminently suitable for a harbour. It was rotected by a rocky headland from all southerly winds; there was small estuary; and there had been formerly a harbour for vessels f small draught, which had been ruined by injudicious reclamation, esulting in the formation of a bar cutting off the harbour. The rift of sand was insignificant, as the sand from the south was leflected by the headland. The charts showed that there had een very little alteration of late years in the coast contours, with he exception of the local silting up on the bar. Docks, jetties and repairing shops could easily be constructed; and the port would hortly be served by three railways. The Singareni collieries would ensure a supply of coal in war-time; and the harbour could be made impregnable at a comparatively small cost. A comparatively small amount of dredging would be necessary to keep the Madras Harbour clear of sand, and he understood that a suction-dredger had been ordered for this purpose. It appeared to him that some arrangements would be advisable at Madras for ensuring the safety of the dredger in the event of a cyclone—for instance, a dock somewhat on the lines suggested by Messrs. Hawkshaw and Mr. Molesworth.

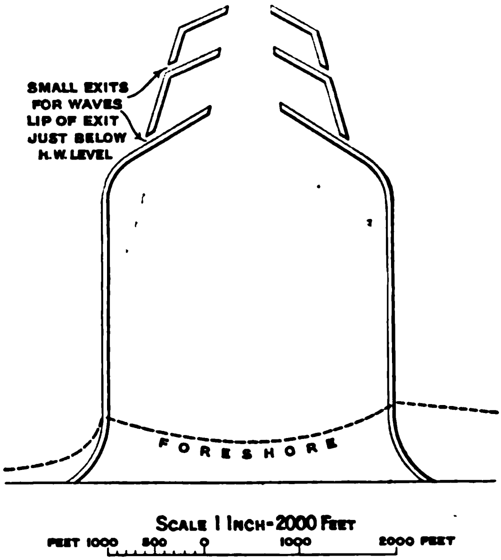
Mr. Molesworth. Dobson: for although he would be a bold man who would take dredger out to sea from Madras in the face of an impending cyclone the man who would try to ride out a cyclone in that harbour would be bolder still.

Mr. Sandeman. Mr. J. Watt Sandeman could not concur in the Author's statement that the effects of ground-swell and of tides were much alike, th action producing terracing. He had often observed terracing beaches produced by wave-action, but never by tidal action. T direction of the tidal current, although parallel to the coast-line deep water, changed in shoal water, and on sandy beaches became nearly normal to the coast-line, when it was too slow move sand or produce terracing. The effect of waves to whi the term "ground-swell" was applied was the same as that ordinary waves, but the former would not cause terracing unl to a very limited extent. As regarded shoaling of harbours co structed on sandy coasts, tidal currents played a very minor part comparison with that of wave-action, and in the majority of ca their velocity was too low to move sand or to produce the effe shown in *Figs. 3–10*. On the other hand, he agreed with the Auth that at all harbour-entrances on sandy coasts, wave-action wou produce the effects shown by *Figs. 12–19*, although he did not agr that isolated shoals would always occur. He also agreed th artificial scour was very limited in its effect, and that depth sand-threatened harbours must in nearly all cases be preserved dredging, as being less costly than works capable of producing t same effect by artificial scour. The latter might, however, be fou economical at harbours such as those in the Bristol Channel, havi a total tidal range of 30 to 40 feet, where a much greater veloc of scour could be brought to bear upon sand at the time of l water. With regard to the formation of bars, it was evident, as sta by the Author, that the deeper the water into which entrance-pi were carried, the less difficulty there was in maintaining depth the channel. There was a limit to the depth at which wave-act moved sand: the revision of soundings by the Admiralty, at w intervals, showed that, generally speaking, contours of the s bottom at depths of about 20 feet and more below low wa remained practically unchanged. Assuming that the heads entrance-piers were carried out to 30 feet at low water, there wou be little or no movement of sand from seaward, and at harbo without rivers carrying detritus there would be no shoaling. few places, however, was it practicable—on account of the cost— carry piers out to such a depth; and in most cases it would be m economical to maintain the required depth by dredging. W

regard to Ceará Harbour, the conditions stated by the Author, and the contours shown by Figs. 21 and 22, Plate 4, led to the conclusion that shoaling had been due, not to the partial blocking and diversion of the equatorial current, but chiefly to stoppage of wave-action upon the area of sea-bottom sheltered by the breakwater; thereby enabling sand, lifted and drifted by wave-action, to accumulate within the sheltered area: and while the equatorial current would no doubt assist such action, yet the same would have happened had there been no equatorial current. The conditions at Ceará, as described by the Author, were such that no harbour there could be kept open, except by continual dredging; as besides movement of sand by the sea, wind-blown sand from the high dunes would quickly overtop any breakwater. He had a case in point at Blyth Harbour where sand dunes existed to the west and south; and until those to the west had been levelled down, he had had annually to dredge large quantities of sand blown into the harbour and channel. The remedy at Ceará would be to make the viaduct portion of the pier closed to the sea, which could be done economically by means of greenheart piling enclosing a rubble filling; to construct a west pier of piling and rubble filling; and to dredge. With regard to Madras Harbour, the course recommended by the Madras Committee appointed by the Indian Government in 1883, namely, closing the east entrance and providing a new entrance at the north-east end of the harbour, would give greater internal tranquillity at the least cost, although a north-east entrance would be more difficult to take in storms. A better effect could be accomplished, although at greater cost, by providing piers to act as wave-traps outside the east entrance, as shown by *Fig. 43*. These piers would reduce waves to about one-ninth of their height when they reached the harbour-entrance. Referring to the concluding remarks in the Paper, he was of opinion that if piers on a sandy coast were constructed in an efficient manner, there should be no risks incidental to them. He agreed that there were many places on the coast without harbour-accommodation where open-piled structures would supply reasonable trade facilities, and could be constructed at comparatively small cost. The whole secret of the stability of such piers lay in keeping the decking and any superstructure above the level of the crests of the highest waves occurring during the highest known tides. He had often observed the effect of seas on open-piled structures during storms, and had never seen waves strike a blow against single piles; nor had he seen or heard of an instance in which piles in an open pier, well driven, had not been able to resist the heaviest seas. Mr. Sandeman.

Mr. Sandeman. There were numerous positions, particularly on sandy coa (Cearà being a very suitable example), where harbours co be economically made by means of piers, constructed of pili spaced a few inches apart and containing a filling of rubble, whi while affording efficient shelter, would not present a solid barr to the sea. As regarded maintenance, he had constructed t such piers which had fulfilled their purpose efficiently; one bei exposed to the action of the sea-worm was constructed of creoso pine timber. It had resisted the worms for 12 years, and c

Fig. 43.



tinued to do so. Another open pier of greenheart timber whi he had constructed in the Bay of Naples had resisted the acti of the *Teredo* for 18 years. Besides economy, the advantage such piers was the speed with which they could be constructe as there was no difficulty in building 1,000 feet of pier in a year

Mr. Shield. Mr. William Shield observed that before the Cearà harbo works were constructed, an almost identical engineering traged with equally fatal results, had been enacted at Port Elizabet Cape Colony, as already described[1] by him to the Institutio

[1] Minutes of Proceedings Inst. C.E., vol. lxxxviii. p. 359.

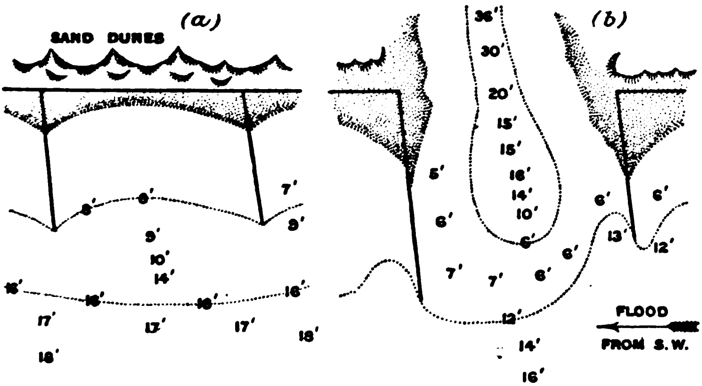
Failures such as these he believed to be largely due to imperfect or faulty diagnosis of the sites, to an inability to discern rightly and profitably the ways and workings of Nature, and to a misconception of the character and power of what were somewhat vaguely termed "littoral currents." For about 30 years he had closely watched the movement of sand on beaches in different parts of the world, and under varied conditions; and he could not but think that what might be called the "flood-tide theory" was based upon a case of mistaken identity. Where the direction of the flood-tide coincided with that of the prevailing winds, as often happened, the mistake might easily be made; but, in his opinion, the doctrine was a dangerous one, and one which, if acted upon, was likely to lead to trouble sooner or later. The evidence in support of the opposite theory, namely, that in the great majority of cases sand-travel along a shore was dominated by wave-action, was to his mind overwhelming. As a notable exception to this rule, the east side of the rock of Gibraltar might be cited. There an nshore eddy-current, which was very little affected by the tides, ran almost constantly in a southerly direction, and undoubtedly governed the direction of the sand-movement. Its velocity ranged from about $\frac{3}{4}$ knot opposite Catalan Bay to $2\frac{1}{2}$ knots per hour at Europa Point. It did not appear to move sand at all except in rough weather, when the sand was stirred up by breaking waves. Under these conditions the sea for about $\frac{1}{2}$ mile from the shore, or out to, say, the 10-fathom or 12-fathom line, was greatly discoloured by sand in suspension, which was carried by the current, as might be clearly seen, into the Straits, where it soon dispersed. With regard to Port Elizabeth, the ordinary sand-drift along the shore from Cape Recife to the town was, at the time referred to, largely supplemented—as at Ceará—by blown sand from an extensive drift to windward, which had an area of about 10 square miles. The prevailing winds were south-east and west to south-west. The south-east wind blew on-shore, and the west and south-west winds off-shore. Along the shore there was an almost ceaseless surf, which, however, was much affected by the wind. The direction of the waves, which never varied more than about two points, was almost dead on-shore, with, however, a slight inclination to the northward which was sufficient to govern the direction of the sand-travel. A strong on-shore wind set up a shore current, which in rough weather might attain a velocity of about 2 knots per hour. This current was due to two causes, namely, to the oblique wash of the waves, and to their lodging water in a temporary trough or channel which they themselves Mr. Shield.

Mr. Shield made by drawing down sand from the beach and depositing it in the form of a bank parallel with the shore. This tripped up the waves, especially about the time of low water, and increased their power of stirring up the sand. It would therefore be gathered that during rough on-shore weather there was a very considerable travel of sand along the coast. A south-easterly gale, as a rule, was almost immediately followed by a westerly gale off-shore, which quickly altered the character of the waves, and imparted to them that subtle function or property, which was perhaps not very well understood, of heaping up the beach. Under these conditions the temporary channel, before referred to, vanished by reason of the altered wave-action moving the sandbank in-shore and again lodging it upon the beach whence it came. With the wave-wash reduced and this channel gone, the current soon ceased altogether, and sand accumulated along the shore with surprising rapidity. These were the main physical conditions affecting Port Elizabeth, a comparison of which with those at Ceará might be of interest to those who knew that port.

Mr. Siccama. Mr. H. T. H. Siccama considered it rather a bold undertaking to fix rules as to the displacements in a sandy bottom, due to artificial causes. There were hardly two even similar instances where the effects were the same. To mention one, there was the entrance to the new mouth of the Maas at Hook of Holland, which, it was true, was altogether due to human agency. A canal had been dug from a point on the Maas to the North Sea, nearly at right angles to the shore-line and to the direction of the flood- and ebb-currents. Before the canal was made so as to communicate with the sea, two groynes were run out as in *Fig. 44* (*a*). In 1868 the 8-foot line of soundings was more or less as in the Author's *Fig. 10*, but the 16-foot line bulged out seaward. In 1872 the canal from the river was cut, and then the contour-lines became as in *Fig. 44* (*b*). The flood tide doing most of the scouring, pools were formed at the north sides at the ends of both groynes, with depths of 12 feet. Inside this 12-foot line was a bar with 6 or 7 feet on it. Farther up the depths increased again. The soundings of 1873 and 1874 showed the same features, and they would probably have remained permanent, had not dredging on a considerable scale been then resorted to. In fact, it was only by steady dredging that a navigable channel was now kept open; and there still remained a tendency for the currents to form pools in the old places. The flood-current from the south-west, sweeping past an obstruction at right angles to its direction, formed eddies on the lee side of the end of the obstruction, and

caused a deepening of the bottom there, as in *Fig. 45.* The entrance to the harbour of Ymuiden (*Fig. 46*) was somewhat like the Author's *Fig. 18*, at least, as regarded the seaward ends of the piers. Here greater depths were sounded next to and outside the pier-ends Mr. Siccama.

Figs. 44.



than farther out, the contours being very similar at both piers. This was probably owing to the fact that the flood-tides from the Channel and round Scotland met in this neighbourhood, and that their action was about equal. There was also a tendency to

Fig. 45.

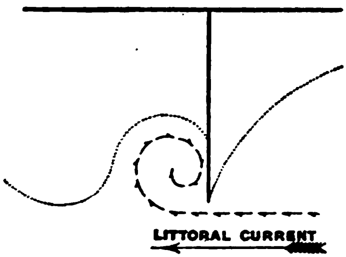
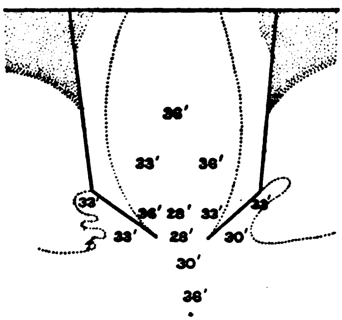


Fig. 46.



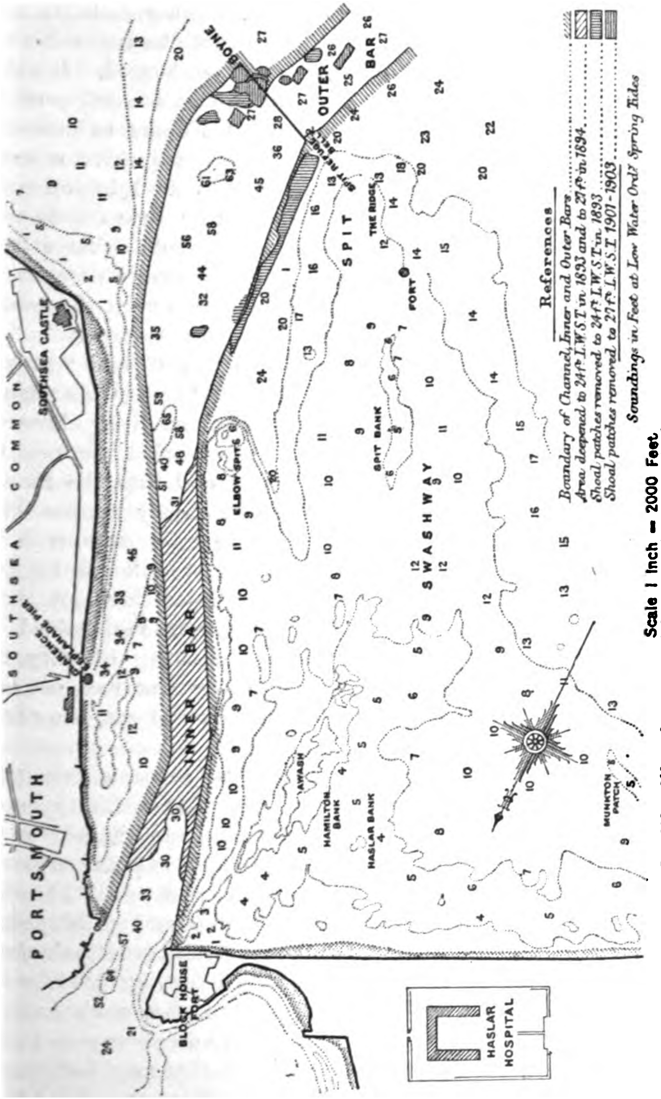
shallowing in the middle of the entrance. A good deal of dredging went on at Ymuiden also, so that there was no saying what Nature would do if not interfered with. With regard to the harbour at Madras, if the form chosen had been as shown in

Mr. Siccama. Fig. 29, Plate 4, there would probably have been less trouble with the sand, as most of it would have travelled past, instead of being held up by a jetty just laid for inviting it inside. Perhaps seafaring men would have objected, but they always did object to any devisable harbour-entrance. Yet, although they grumbled, it must be said to their credit that somehow they got in all right. The new Flushing Harbour, for instance, had an entrance nearly at right-angles to the direction of the strong flood- and ebb-currents on the Scheldt running at 5 miles per hour or more, leading into a short basin. Steamers had to rush in at full speed and then bring up in two or three times their length, if they did not want to run into a stone-pitched dam at the end, placed there as a sort of buffer-stop. This harbour was as badly designed as could be imagined; and yet the mail-steamers got in twice daily in all weathers, successfully so far.

Mr. Sims. Mr. T. SIMS remarked that to any one interested in the study of the effect of tides and of hydrographic conditions in the vicinity of harbours, the chart of Portsmouth Harbour was extremely interesting. The entrance to the harbour appeared to have been always naturally blocked by the vast "Spit" Bank and shallows covering a triangular area of about 2 square miles. The apex of this triangle was at the north, and led directly to the entrance to the harbour. The effect of ebbing and flowing tides from and to the harbour seemed to have caused a channel to be cut through the shallow bank along the north-east side of the triangle, parallel to the shore (Southsea Beach), and extending from the old town of Portsmouth to Southsea Castle, and seaward towards the Outer Bar (*Fig. 47*). The Inner Bar ran from Block House Fort in a south-easterly direction, its nominal seaward limit being its intersection with the Outer Bar on a line which joined the "Spit" Fort on the west side to the "Boyne" Buoy on the east. Records showed that the original depth of channel over the Inner Bar was very moderate. In 1860 it was increased by dredging to 13 feet at low water of spring tides in 1861 to 17½ feet, and in 1872 to 20 feet. A survey made in August, 1887, showed that the increased depth so obtained had generally been maintained. In 1891 it was decided by the Admiralty to dredge the bar to a depth of 24 feet at low water of spring tides; this work was completed in 1893. Following on this, further deepening to 27 feet was undertaken, and completed by the end of 1894. Various surveys had been made since that date, which tended to show somewhat uncertain variations in depth of water over the bar from time to time. The last survey, in 1901, showed the average depth

of water to be about 29 feet at low water of spring tides. There was strong reason for hoping that the increased depths obtained Mr. Sims.

Fig. 27.



Entrance-Channel to Portsmouth Harbour.

by dredging would be maintained without much silting. It was thought that the reason for this satisfactory result might be partly

Mr. Sims. attributed to the possibly increased scour due to the considerabl quantity of mud-land above low-water level which had bee removed from within the harbour during the past few years; an as much yet remained to be removed, further benefits wer anticipated. It scarcely seemed probable that the Inner Bar wa in process of formation by a silting up of the channel. It rathe appeared that this hard bank of shingle was a portion of th original shallow "Spit" Bank, which was too dense to be scoure away by the ebb and flow of the tide. This conjecture was sup ported by experience which had followed each dredging-operatio to obtain increased depths, which showed that such depths wer generally maintained. It was interesting to notice that at eac end of the Inner Bar there was a deep hole of over 60 feet at lov water of spring tides, which did not appear to silt up to the level o the shallower depths as might perhaps have been expected. The Outer Bar extended southward from the "Spit" and "Boyne" Buoys until deep water was met with south of the Outer Spit, a distance of about 1,300 yards to the 5-fathom line. Here the action of the currents had a very different effect, because the stream of water ebbing and flowing out of and into the harbour was no longer confined within the comparatively narrow limits of the channel, but was spread over a large water-area, with the result that the action of the currents had been found to cause a considerable amount of silting on the Outer Bar. A depth of 26 feet at low water of spring tides was maintained by occasional dredging of shoal patches consisting of very fine sand. No extensive deepening of the Outer Bar had yet been undertaken, but should such operations be carried out, the results would be extremely interesting.

Mr. Thorpe. Mr. W. H. Thorpe thought further information respecting Santa Ana harbour was much to be desired. The Author appeared to consider it surprising that the entrance had shoaled as the result of a storm, but it seemed reasonable to suppose that this harbour would of necessity be in a critical condition. The tidal capacity, estimated from Fig. 1, Plate 4, worked out at 240 million cubic feet. The flow at half-tide through the channel, calculated upon an average section of 450 feet by 76 feet by 0·75, would probably be at a mean velocity of about 8½ inches per second, or, say, 6 inches at the channel-bed, and at the narrow entrance some 50 per cent. greater. From this it appeared that no tidal scour of any importance existed. It would be instructive, he thought, to know whether the lagoon had originally been larger, and had shrunk to its present area—as a result of silting—till

the current through the channel was no longer able either to convey the silty matters, or to expel them if brought in bodily by storms. The diagrams of typical cases might be of real service in helping to separate the effects of influences at work in more complex cases. Effects produced by causes acting from a considerable distance were, he submitted, at times apparent. As an instance of this might be cited, if the reasoning were accepted, what had happened in the vicinity of the mouths of the rivers Mersey and Dee, since the Mersey bar had been dredged. Within the rectangular area of which the Lancashire coast formed part of the eastern side, and the Cheshire coast part of the southern side, containing about 120 geographical square miles, there had been during the last 11 years shoaling amounting in the aggregate to fully 250 million tons, and a sensible accretion to the banks on either side of the main channel, with here and there some reduction. The result of dredging about 50 million tons appeared to have been, by providing freer passage of tidal water through the bar, to reduce the velocity in approaching and passing over the banks, when these were covered, thus permitting the deposition of silt in large quantities. There had also been a considerable sanding-up of the Rock channel, and some alteration, both by accretion and reduction, of the Hoyle banks. The effect of the dredging, he suggested, extended a distance of 9 miles in a direct line, or measuring along the main channel, the Rock channel and across the Hoyle banks, a distance of 17 miles; and he thought it probable these changes would become more marked till the Rock channel became blocked for some time after low water, with the ultimate consequence of the eastern arm of the Dee breaking through the East Hoyle bank and re-establishing Hoylake, which 200 years ago was a wide and deep channel. That Hoylake did not become closed, and would not of necessity remain so, as an after-result of works carried out in the upper Dee in the early part of the eighteenth century, was evidenced by the fact that the first part of those works, the diversion of the Dee river through a new cut 10 miles long, was not brought into use till April, 1737,[1] whereas the Hilbre channel had broken through the Hoyle bank and Hoylake was in process of closing previous to that date, as shown on a chart dated 1736. In conclusion, he ventured to think it probable that dredging on the Mersey bar might later have become little, if at all, necessary Mr. Thorpe.

[1] T. Baines and W. Fairbairn, "Lancashire and Cheshire: Past and Present," vol. ii. p. 98. Lond. 1869.

Mr. Thorpe. where now carried on, for the maintenance of the 27 feet depth, though a new bar would probably form in deeper water, which might or might not be kept down by dispersal in the more exposed situation.

Mr. Vernon-Harcourt. Mr. L. F. VERNON-HARCOURT remarked that the subject submitted by the Author was of great importance, and surrounded by difficulties. A Paper on "Harbours and Estuaries on Sandy Coasts" was read at the Institution 22 years ago,[1] and perhaps, owing to the lapse of time, was unknown to the Author, as he had not alluded to it; but the discussion and correspondence on that Paper, which raised the various points with which the Author had dealt, should not be allowed to be buried in oblivion, for several eminent engineers who had taken part in that discussion had since passed away; and out of eighteen persons who joined in the correspondence, thirteen were foreign engineers having special experience on the subject in Holland, Belgium, France, and Italy. Two important and elaborate publications had appeared since then, on the formation and maintenance of harbours upon sandy coasts, which might be consulted with advantage; one in 1889, by Mr. Eyriaud des Vergnes,[2] the engineer who introduced suction-dredging, in place of sluicing-basins, for maintaining and deepening the approach to Dunkirk Harbour; and the other in 1894, by the late Mr. P. de Mey,[3] who initiated the improvement of the access to Ostend Harbour by dredging channels across the Stroombank, to which the Author had referred. In his references to Dunkirk, Ostend, and Madras harbours, the Author necessarily traversed similar ground to that of the earlier communication, with the addition of subsequent particulars, and instances of harbours recently constructed or proposed; and the most novel features of his Paper were his diagrams of the effects of littoral drift under different conditions, and his proposal to evade the difficulties of maintaining harbours upon sandy coasts, and the expense their construction and maintenance entailed, by resorting to open pilework piers for the discharge of cargoes at towns on the sea-coast. *Figs. 3–20* appeared to be based on the Author's views of the effects the littoral currents, due to tides and wind, produced on a sandy foreshore, when solid obstructions, or the discharge from rivers, impeded their progress; for no instances were cited in

[1] Minutes of Proceedings Inst. C.E., vol. lxx. p. 1.

[2] "Étude sur l'établissement et l'entretien des ports en plage de sable," *Annales des Ponts et Chaussées*, 6th series, vol. xvii. p. 185.

[3] "Étude sur l'amélioration et l'entretien des ports en plage de sable et sur le régime de la côte de Belgique." Paris, 1894.

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support of them. The accretion shown in *Figs. 10* and *19* might, indeed, be regarded as approximately correct, and also the absence of accretion in *Figs. 11* and *20* with an open viaduct or pier; but the others, showing outlying shoals, appeared open to question. Undoubtedly a bar was found in front of a river-outlet or jetty channel, somewhat in the positions occupied by the shoals in *Figs. 3–6* and *Figs. 12–15*; but a bar, instead of being a shoal rising, as shown, above low water, was really a part of the outlet-channel across a shallow foreshore, where the issuing current, in gradually losing its scouring efficiency, was not able to maintain as deep a channel as near the outlet, before reaching deep water outside; and the depth over the bar was greater than that on the foreshore on either side of it. The tendency, indeed, of the checking of the littoral currents by the discharge from a river or jetty harbour, at right angles to the coast, was to raise the foreshore somewhat on each side of the outlet-channel where the littoral currents were fairly equal in both directions, as at the mouth of the Maas; and on the windward side of the channel with a prevalent wind in one direction, as evident on the northern side of the Yare outlet, and the western side of the approach-channel to Dunkirk Harbour. The diversion also of the outlet of rivers with a small tidal and freshwater discharge, was clearly due to the accumulation of drift on the windward side of the outlet-channel, and to this drift being driven along the coast by the strong prevalent winds, so as to force the outlet to travel to the leeward, till the discharge could find an escape through a weak place in the beach, or the increase of the tidal volume in the lengthened channel, aided in some cases by a leeward jetty across the foreshore, gave the discharge sufficient scouring power to form a permanent outlet in spite of the drift. Moreover, at the outlet of a lagoon harbour such as Poole, of which he had recently examined all the principal charts extending back to the eighteenth century, there were no signs of a detached shoal in front, as shown by the Author in his diagrams; but the outlet-channel, which was deflected by the south-easterly winds to which it was mainly exposed, gradually shoaled to a bar before reaching deep water, on which, however, the depth was greater than on the adjacent sandbanks which bordered the outlet-channel.[1] In the various charts of sandy bays which he had examined, there was no evidence of a central outlying shoal, such as was shown in *Figs. 6, 7, 15*, and *16*. It seemed

[1] L. F. Vernon-Harcourt, "Report on Poole Harbour Protection." Poole, 1903.

Mr. Vernon-Harcourt. also hard to understand, on comparing *Figs. 9* and *18*, why effect of the addition of the action of a prevailing wind to tidal littoral drift, in *Fig. 18*, should reduce the amount of accret on the outer side of the windward breakwater, instead of increas it; or why it should obliterate the curious, central, detached sh shown inside the harbour in *Fig. 9*, and produce an increa quantity of silting inside the harbour? As the Author obser there were two main types of harbours upon sandy coasts, the chiefly natural, extending inland and having a narrow outlet the sea-coast, and the other artificial, formed by one or two bre waters carried out across the sandy foreshore of the open sea-co The first type consisted of lagoons, or wide expanses inland bel sea-level, into which rivers flowed near the sea-coast, such as Chr church, Wexford, and Poole harbours, and the ports of Cal Dunkirk, and Ostend, whose outlet-channels had been guided jetties across the beach; and, lastly, distinct river-outlets giv access to ports inland, in which the freshwater discharge mi exercise an important influence, as in the case of the outlet of Maas across the Hook of Holland. Lagoon harbours, and the je harbours of the North Sea coast, had maintained a good depth past times at their outlets, mainly owing to the scour of the ti ebb and flow emptying and filling extensive areas shut off fr the sea by sand dunes; but gradual silting in the lagoons, fr the flood-tide bringing in sand which the ebb-tide did not wh carry out again, had often diminished the tidal scour by deg and, consequently, the available depth over the bar at the ou while extensive reclamations, as carried out in Wexford Harb and especially at Calais, Dunkirk, and Ostend, had greatly red the tidal scour through their outlets. An effort had been m at these latter harbours to restore the tidal scour, by form sluicing-basins in the lowlying land adjoining the entra which were filled by the rising tide, and emptied at low wa but a bar had remained in the outlet channel seaward of entrance, in an awkward position both for navigation and remo and, accordingly, in 1875 suction-dredging was comme in the outlet channel at Dunkirk, to assist the tidal scour, cost of 1*s.* 9*d.* per cubic yard, which had been reduced by to slightly under 3*d.* In proportion as the expenses of suct dredging had been lowered, the operations had been exten and the sluicing-basin at Dunkirk had been replaced by do while suction-dredging had also been resorted to for deepe the outlet channels at Boulogne, Calais, and Ostend, far bey the limits attained by scour from the sluicing-basins. In fac

stated by Mr. Eyriaud des Vergnes at the Paris Navigation Congress in 1900, sluicing-basins had now been quite abandoned in France in favour of suction-dredging;[1] and the construction of the new sluicing-basin at Ostend[2] was regarded by French and Belgian engineers as the last relic of antiquated views. The Author appeared, from his remarks on p. 6, to have not quite rightly appreciated the object of dredging the eastern channel across the Stroombank, near the entrance to Ostend Harbour, which was clearly stated in Mr. P. S. Van der Schueren's Paper[3] on the works at Ostend Harbour, read before the Third Section of the Paris Congress of 1900. The flood-tide running up along the edge of the Stroombank, in a north-easterly direction, had been gradually silting up the north-eastern end of the channel running past the entrance to the harbour, between the Stroombank and the shore, thereby tending to connect the bank with the coast, and had thus been checking the run of the flood-tide along the inshore channel,[4] which action had been producing a shoaling of the channel in front of the entrance. The eastern channel had, accordingly, been dredged to open out again the inshore channel at its north-eastern end, restoring the condition shown on the chart of 1804, and thereby preserving the scour of the tidal currents through this channel. When an artificial harbour was formed by breakwaters extending out across the foreshore to deep water on a sandy coast along which there was a littoral drift, these breakwaters naturally acted as groynes in arresting the drift, and produced an advance of the foreshore. This was manifested by an advance of the beach and of the lines of soundings to a moderate extent on each side of Ymuiden Harbour at the North Sea entrance to the Amsterdam Ship Canal; by a considerable progression of the sandy foreshore on the western side of the west breakwater at Port Said; and by the unexpectedly rapid advance of the shore on the southern side of the south breakwater of Madras Harbour, so that now the travel of sand from the south had overlapped the outer end of this breakwater and commenced silting up the entrance at the rate of 1 foot per annum. The advance of the foreshore at Ymuiden appeared to have reached its limit, and at Port Said had become quite slow; and the silting inside these harbours and at their outlets was removed periodically, without difficulty, by dredging. At Madras

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[1] VIIIe Congrès international de Navigation. "Compte rendu des Travaux." Paris, 1900, p. 500.
[2] Minutes of Proceedings Inst. C.E., vol. cxxxvi. Pl. 6, Fig. 17.
[3] "Travaux . . . à l'atterrage et au port d'Ostende," p. 4.
[4] P. de Mey, "Ports en plage de sable," Atlas, Pl. 8.

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the drift of sand from the south was quite exceptionally large; and there appeared to be some danger that the travel of the sand, after passing the outer end of the harbour and proceeding northward, might impede the access to the proposed northern entrance by the sand being deposited under shelter of the projection of the harbour beyond the proposed sheltering breakwater. The Author was mistaken in attributing the abandonment of St. Catherine's Harbour, Jersey, to its obliteration by sand-drift. When resident engineer at Alderney Harbour, Mr. Vernon-Harcourt had also had St. Catherine's Harbour under his charge, and he had visited it on two or three occasions. The works were stopped after the completion of one of the breakwaters, because, as stated in his Paper on Alderney Harbour, "the Admiralty decided that the harbour was not required, and should be abandoned."[1] He was unaware of the present condition of St. Catherine's Bay; but, though some silting up had occurred in the bay when he visited it 15 years after the termination of the works, as the natural result of the projection of a single breakwater like a groyne, the sections he then took across the rubble mound of the breakwater towards the outer end, showed a depth on the inner side of the breakwater of 35 feet at low water of spring tides and 67 feet at high water;[2] and therefore, even at that time, the harbour could not be described as obliterated by sand-drift. The Author, after indicating in *Figs.* 8 and 17 his views of the effects of carrying an open viaduct across a sandy foreshore, before commencing a solid sheltering breakwater, gave Ceará Harbour as an example of this form of breakwater, exhibiting results entirely at variance with his theory. Rosslare Harbour, however, on the east coast of Ireland, a few miles to the south of Wexford, of which he had superintended the commencement,[3] and which, after being stopped for many years for want of funds, had recently been extended with successful results, was a more favourable example of this type of construction. Zeebrugge Harbour, in course of construction in the North Sea at the entrance to the Bruges Ship-Canal, was another instance of a sheltering breakwater approached by an open viaduct across a sandy foreshore, subject to littoral drift;[4] and the results of this work, designed to avoid the deposit of drift inside the harbour

[1] Minutes of Proceedings Inst. C.E., vol. xxxvii. p. 75.
[2] *Ibid*, vol. xxxvii. Pl. 6.
[3] *Ibid*, vol. lxx. p. 50.
[4] *Ibid*, vol. cxxxvi. p. 285; and vol. cxlv. p. 319.

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when completed, would be of considerable interest with reference to the maintenance of harbours on sandy coasts. All the methods of construction of harbours on sandy coasts referred to in the present Paper, had been mentioned and had found advocates in the discussion and correspondence on the earlier Paper; and in his reply to the correspondence, he had summed them up as follows: "(1) The jetty system; (2) Closed harbour with converging solid piers; (3) An outlying, detached solid breakwater; and (4) One or more sheltering breakwaters connected with the shore by one or two open viaducts."[1] A detached breakwater, parallel to the shore, had not as yet been constructed in front of a sandy coast, with the object of providing shelter without impeding the travel of drift; but this system had been suggested for Ostend,[2] and had been proposed, as shown by the Author, for some harbours in Denmark. The last form of harbour had hitherto been restricted to a single open viaduct, stretching out across the foreshore, leading to a solid breakwater curving round and extending parallel to the shore. The construction, however, of an outlying harbour, protected by breakwaters and connected with the shore by a viaduct, on the principle of *Fig. 26*, had been suggested by Mr. Redman for sandy coasts like those of Belgium, and had been mentioned by Dr. Pole as proposed by Mr. Dupuy de Lome for Calais, in the discussion on the earlier Paper in 1882; and he had himself, in his reply to that discussion, besides alluding to Sir Andrew Clarke's scheme for Madras, resembling in principle Rosslare Harbour and the design for Port Elizabeth, referred to a design he had seen for Madras Harbour, in which the only difference from *Fig. 26* was that the inner breakwater was curved as well as the outer.[3] Nevertheless, though no novel principle had been evolved for the construction of harbours on sandy coasts in the 22 years which had elapsed between the two Papers, the Author had rendered a valuable service to the Institution in bringing forward again this interesting subject for discussion, in a Paper which furnished several new examples. The chief change in practice which had occurred in this period was the practical abandonment of sluicing-basins, and the general adoption of suction-dredging; and the gain in experience was the success which had attended the lowering of bars, and the deepening of approach-channels, by sand-pumps at a moderate cost, and the great drift of sand along the coast which took place in certain localities, as exemplified by the shoaling

[1] Minutes of Proceedings Inst. C.E., vol. lxx. p. 100.
[2] *Ibid*, vol. lxx. p. 87.
[3] *Ibid*, vol. lxx. pp. 41, 45, 49, and 52.

Mr. Vernon-Harcourt. at Madras and Ceara harbours. The accumulation of sand against the south breakwater at Madras, where the tide was feeble, and also against the west breakwater at Port Said, where there was no tide, demonstrated forcibly the predominant influence of the prevailing winds in causing littoral drift; though in the absence of wind, the somewhat greater power of the flood-tide than of the ebb, except where counteracted in rivers and estuaries by the freshwater discharge, should produce a moderate travel in the direction of the flood-tide. In conclusion, though it was impossible to build harbours on any site where funds were not available, and where there was little trade to afford a return on the expenditure, there appeared to be no reason to abandon the construction of harbours on sandy coasts where they were really required, except possibly at such exceptionally unfavourable sites as Madras and Ceara. Jetty harbours, deepened and maintained by sand-pump dredging, provided valuable facilities for passenger traffic and trade, as exemplified by Calais, Dunkirk, and Ostend, and also the outlets of rivers guided by jetties across a sandy foreshore, regulated by training-works, and improved by dredging, as illustrated by the Maas, the Tyne, the Tees, and various other rivers. Closed harbours had proved very satisfactory, even in somewhat unfavourable localities, such as Ymuiden and Port Said; and an outlying breakwater approached by a viaduct across a sandy foreshore, afforded a fair prospect of successful results under ordinary conditions. An outlying harbour enclosed by breakwaters would necessarily be very costly; but possibly a detached breakwater parallel to the coast might, under certain circumstances, provide adequate shelter to landing places and quays adjoining the shore, without impeding the littoral drift.

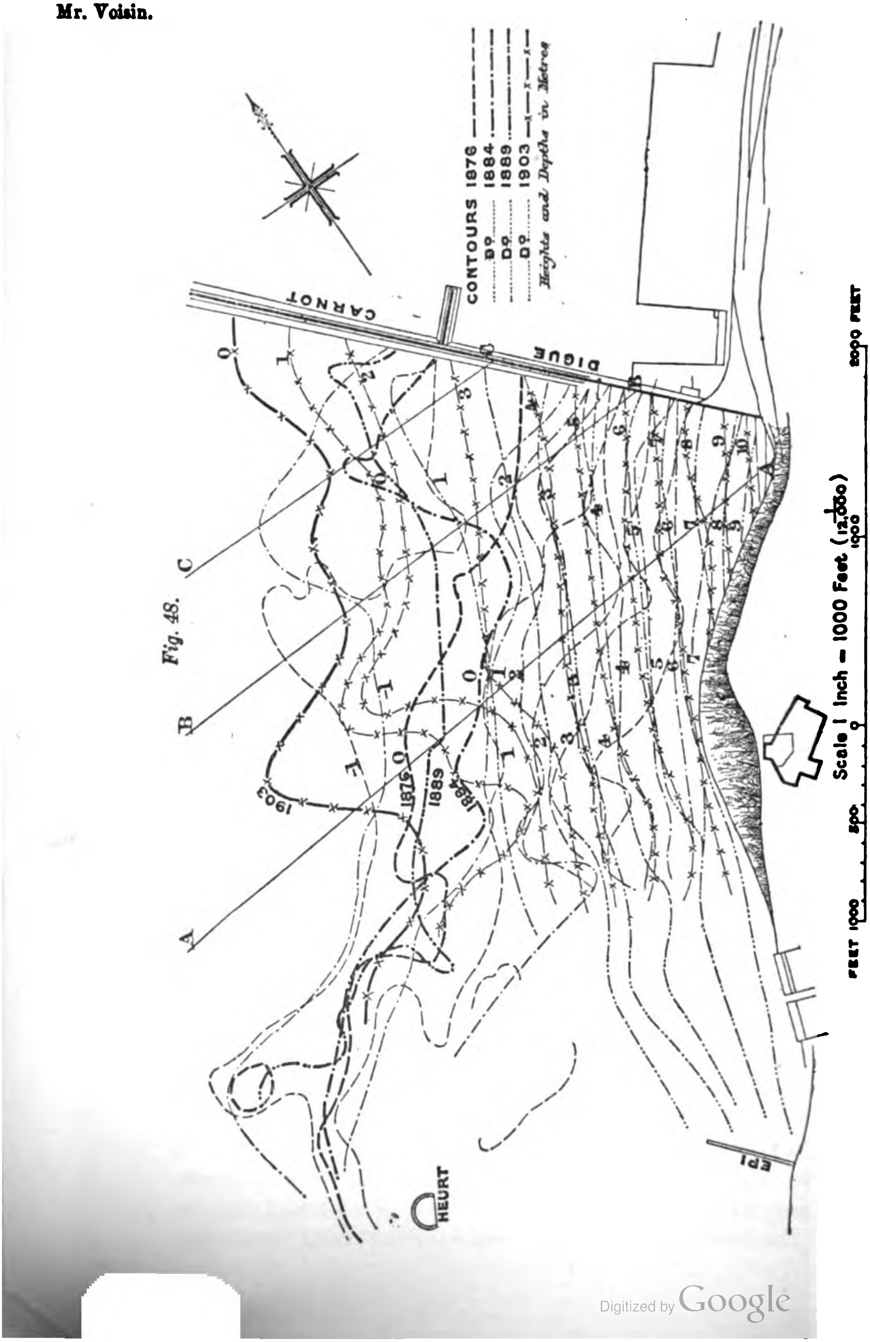
Mr. Voisin. Mr. VOISIN, of Boulogne-sur-Mer, believed that, in the main, the views so ably put forward by the Author were incontrovertible. They were, however, perhaps a trifle too generally stated, since, in addition to the currents produced by the ebb and flow of the tide, the velocity of these currents, the calibre of the sand-grains, and the predominating winds, it appeared to him to be particularly necessary to take into account the slope of the sea-bottom in the vicinity of the coast, and certain other local conditions. These could not all be so far included as to render it possible to formulate, as the Author had done, a set of laws which would be generally applicable. It was, in fact, necessary to investigate in each particular case whether there [illegible] not be certain special circumstances to which more or

less weight should be attached. The depth of water shown at Boulogne presented an interesting exemplification of this twofold aspect of the subject. In conformity with the laws laid down by the Author, the general drift of the sand tended to take place from south to north, consequent upon both the superior velocity of the flood-tide and the prevailing direction of the winds, which blew along-shore either from the south or west; and thus, since the completion of the Carnot breakwater in 1889, there had been a considerable accumulation of sand against the weather side of the pier and a corresponding denudation to leeward, that was to say, on the eastern side of the Boulogne coast-line. As would be evident from the accompanying profiles (*Figs. 49*), however, the shoaling was confined to depths of 4 to 5 metres (13·1 feet to 16·4 feet) below datum in such a measure that there would seem to be but little likelihood that any important part of the spit of the foreshore or of the base of the pier would be silted up; on the contrary, the soundings tended to increase in depth towards the outer extremity of the piers (*Figs. 48* and *49*). The reason of this was, as had been foreseen at the time the works were planned, that in this part of the offing they were being placed on the summit of a submerged cliff, the upper part of which was 8 to 10 metres (26·2 to 32·8 feet) below datum, having steeply sloping sides reaching down to a hard bottom at 15 to 20 metres (49·2 to 65·3 feet) below datum. These cliffs constituted the banks of a veritable submarine river, which had been, so to speak, in no way interfered with by the above-mentioned works; and, owing to the depth of its banks and the nature of its bed, this river conveyed but little sand. This was, in fact, an illustration of special local circumstances needing consideration, to which he had previously alluded. While, therefore, the general accuracy of the conclusions arrived at by the Author was established, namely, that tidal sea-ports could be maintained free from sand only by dredging, there might yet be peculiar local conditions under which the amount of this dredging might vary very considerably. This might be what the Author had implied at p. 219 of the Paper. Such was the case at Boulogne, since the ordinary maintenance of the requisite depth of water in the port entailed the removal of rather more than 360,000 cubic metres (470,880 cubic yards) annually, at a yearly cost of about 70,000 francs (£2,800), which, in view of the results obtained, did not appear to be extravagant. It was, moreover, necessary to state that a considerable part of these deposits originated from the solid matters discharged by the sewers of the town into the inner harbour, and from the erosic

Mr. Voisin.

Mr. Voisin.

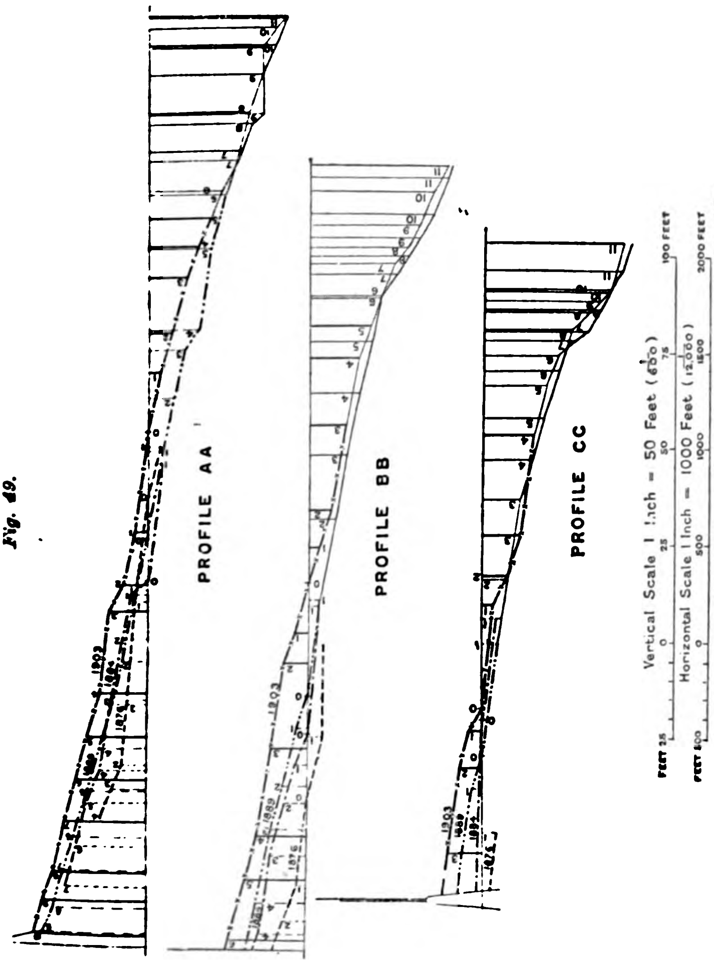
Fig. 48.



CONTOURS OF THE FORESHORE AT BOULOGNE-SUR-MER, 1876–1903.

produced in the narrow torrential valley of the River Liane, which flowed into the port. A further example, which corroborated the facts represented by *Fig. 20*, was furnished by the little sea-wall at Le Portel, a port situated about 5 kilometres (3·1 miles) to the Mr. Voisin.

Fig. 19.



PROFILES OF THE FORESHORE AT BOULOGNE-SUR-MER, 1876–1903.

south of Boulogne. This pier, which had been pierced with a series of openings, had not sensibly modified the soundings in its vicinity, and had nevertheless had the result of producing a very appreciable amount of shelter on the coast of Le Portel, as desired.

Mr. Wheeler. Mr. W. H. Wheeler remarked that the intention of the Paper, as expressed by the Author, was to show how littoral drift along a coast tended to sand up harbours, but the examples (*Figs. 3–20*) of the effects of various forms of breakwaters for the purpose of providing against this, and for maintaining a depth of water sufficient for navigation, appeared to be purely theoretical. If examples had been taken from existing harbours, they would have been much more instructive. In a Paper,[1] which he had presented to the Institution in 1895, he had contended that if breakwaters were carried out from the coast into water of sufficient depth, the channels would be free from the action of the littoral drift and be beyond the local influence of matter drifting along the coast, and would maintain their depth. The least depth that had been found sufficient in practice was 2½ fathoms, and sand and shingle never drifted round the end of a breakwater terminating in a depth of 4 fathoms. Several examples of existing harbours were given in the Paper, some of which fulfilled this condition and were successful, and others which had not failed to maintain deep water. It was also shown that although the extension of a breakwater out from the coast where there was much drift resulted in the accumulation of material on the windward side, this deposit ceased after it had extended out for a certain distance; owing to the supply being cut off by the protection afforded to the cliffs by the raised beach, or, in the case of a sandy beach, by the slope becoming so steep that sand put in motion by the waves was carried out to sea during the receding of the tide, and did not drift along the shore. He was also of opinion that the maintenance of depth in a breakwater channel was facilitated by giving it a slightly curved form, the line of curve extending away from the direction from which the drift came. The scouring action of both flood- and ebb-tide was thus increased by running round the inside of the curve, and the deepest channel was always maintained in one place; the force of the water was also concentrated on any deposit that tended to collect and form a bar at the end of the piers. The curved form also, while forming no obstacle to the approach, covered the entrance and afforded shelter within. In some cases a single curved channel on the windward side of the entrance had been found sufficient to maintain a deep-water channel and prevent the formation of a bar. The Author in his examples had not dealt

[1] "Littoral Drift: in its relation to the Outfall of Rivers, and to the Construction and Maintenance of Harbours on Sandy Coasts," Minutes of Proceedings Inst. C.E., vol. cxxv. p. 2.

with channels of a curved form. The example of the harbour at Curaçao appeared to confirm these views. The mouth of the harbour was in 15 fathoms of water, and along the channel, which was slightly curved, the depth was 10 to 13 fathoms, while in the lagoon with which it communicated there was only 6 to 8 fathoms. At Ceará the depth was stated to be 3 fathoms, and the sea with which it communicated was so shallow that only 5 fathoms was reached at 3 miles out. With such shallow water failure seemed to have been invited by making the breakwater open next the shore, thus allowing the sand drifting along the coast to pass through this open work into the channel. It did not, as the Author stated, outflank a solid barrier, but passed through the open viaduct into and across the channel. Mr. Wheeler.

The AUTHOR, in reply, was fully in accord with the final decision against the proposal tentatively put forward by the late Mr. James Abernethy to convert the River Esk at Whitby above bridge into a sluicing-basin, as described by Mr. Austen. The only effect would have been, in his judgment, to dig a pit immediately seaward of the bridge, and to leave the harbour-entrance probably in a worse state than if scour had not been attempted. He thought the port might be materially improved at small cost by the construction of an open-piled pier on the east side. He had not seen Mr. Richardson's paper referred to by Mr. Benedict. The size of an estuary and the volume of its freshwater discharge were obviously correlative, and the configuration of an estuary was thus largely moulded by the effluent. Mr. Bent's statement as to Ceará Harbour proved that delay on the part of the Brazilian Government had prevented the adoption of a measure which might have resulted in greater complications than those actually experienced. The projection of a solid groyne to windward of the harbour would necessarily have produced erosion to leeward of such groyne. When the altered contour of low-water line, due to the new obstruction, became permanent, the drift of sand would have resumed its previous travel, and, gorging having taken place, fresh accretion along the frontage of erosion would have resulted. He understood from Mr. Dyce Cay's remarks that he advocated a system of groyning on the outer side of breakwaters built of rubble. Such groynes, or spurs, would be almost as costly to construct as corresponding lengths of breakwater, and should surely be unnecessary. The Author of course did not propose the abandonment of harbour-construction on the lines of established practice. His contention was that in many instances a piled structure could be designed at a fraction of the cost of a solid breakwater, and give The Author.

The Author. reasonable trade facilities. It seemed to him misleading to induce a Government or local authority to embark on the construction of a harbour so designed that the inevitable result must be either sanding-up, or permanent expenditure for dredging, unless those factors were previously clearly defined. With regard to Mr. Mann's statement as to the incompleteness of the facilities provided by a piled structure, these were admitted; but he thought the actual results attained at Port Elizabeth, Cape Colony, and detailed by Mr. Shield, furnished a sufficient justification for the suggestions contained in the Paper. He was entirely at one with Mr. Metcalfe as to the necessity of exhaustive data before any harbour-works could be satisfactorily laid out. Such information as could be obtained from local fishermen and others was often unreliable. If their preconceived theories came into collision with facts it was frequently the worse for the facts. One source of possible miscalculation in the studies for sea-works was the difference between superficial and bottom currents. Mr. Molesworth's remarks as to the coast of India emphasized the views of the late Sir Andrew Clarke. His statement [1] was—

> "They had between Calcutta and Bombay a coast-line of 2,300 miles, in which a steamer could not go alongside a wharf to discharge its cargo. That was a disgrace both to the Government of India and to this country. Due to this want of communication he had no hesitation in saying that, in the famine of 1877–78, no less than between three and four millions of their fellow-subjects perished."

The Author fully agreed with Mr. Sandeman that wave-action was the primary cause of sand-movement; but the sand once being stirred up by the waves, and thus in suspension, it was capable of being transported by a comparatively feeble tidal current. The Author's remarks as to terracing under the action of ground-swell had reference to the terracing of beaches, not of sand. With an oily sea and ground-swell dead on, this action was pronounced and rapid. It might be stated generally that on an undisturbed coast-line there was little or no movement of sand along a sea-bottom beyond a depth of 24 feet, but when solid works were projected into the sea, as was evidenced at Madras, these effects took place at much greater depths than this. He doubted whether Mr. Sandeman's suggestion of wave-traps for Madras, as shown in *Fig. 43*, would be an improvement on the original design. Their effect would be to plough up the sand near the entrance to the harbour, and they would also result in a gorging of the water

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[1] International Maritime Congress, 1893. Proceedings of Section I. p. 172.

in the harbour itself. It was obvious from the graphic description given by Mr. Thorowgood of the harbour of Madras in a cyclone, that this gorging, which had raised the level of the water inside the harbour to a higher level than that outside, had, in the cyclone which wrecked the harbour, caused the sea-walls to fall outwards. With regard to Mr. Thorpe's reference to St. Ana Harbour, the hurricane on record previous to that of 1877 took place in 1807, and the Author believed that the general conditions, both as to the lagoon and the harbour-entrance, had remained practically constant up to the sudden narrowing of the latter in 1877. In reply to Mr. Vernon-Harcourt's remarks, the Author was not aware of any discussion on the question of Madras Harbour at the Institution, although the ports of Dunkirk and Ostend had been referred to on previous occasions. The diagrams *Figs. 3–20* were put forward to illustrate the effects of the littoral forces. They represented types of normal harbours and harbour-entrances, and illustrations of them would readily suggest themselves—most readily to Mr. Vernon-Harcourt. Citing instances in each case would have resulted in a very voluminous Paper; and many illustrations had been referred to during the discussion. The Author did not intend to imply that the shoals marked on *Figs. 3–6* and *12–15* would necessarily be visible above low water, but that the tendency to shoal would be in the localities indicated. His view appeared to be supported by Mr. Vernon-Harcourt. There was no doubt that in a harbour as shown in *Fig. 18* the littoral drift on the windward side would tend to accretion, as compared with that in *Fig. 9* under tidal effect only, and conversely on the leeward side to denudation. With regard to the reasons for the cutting of the eastern channel across the Stroombank at Ostend Harbour, Mr. Van der Schueren's actual statement[1] was:— The Author.

"Les dragages qui s'exécutent ont pour but de couper la jonction qui s'est opérée graduellement depuis un siècle et de créer une nouvelle situation se rapprochant de la configuration hydrographique accusée par les plans de sondages dressés en 1801. Sur ces plans figurént des profondeurs de 8 mètres sous marée basse de vive eau ordinaire, là où en 1897, époque qui marque le commencement des travaux, on ne sondait guère plus de 4 mètres. Ainsi que les études de feu M. l'ingénieur en chef de Mey l'ont montré, c'est à l'action des courants de marée qu'on doit attribuer le comblement progressif de la dépression séparant le Stroombank de la côte. Au moment de son maximum d'intensité, le courant de flot suit une direction sensiblement parallèle à celle du banc. En s'appuyant sur le talus Nord du plateau, il entraîne peu à peu les sables le long de celui-ci. L'action combinée des courants de marée se traduit par un déplacement définitif des sables vers le Nord-Est, sous l'effet

[1] "Travaux . . . à l'atterrage et au port d'Ostende," p. 4.

The Author. prédominant du courant de flot; et par la formation de dépôts à l'extrémit correspondante du banc. La modification qui s'est produite ainsi dans l configuration du Stroombank n'a pas laissé d'exercer son influence sur l situation des profondeurs dans la petite rade. Celle-ci s'est trouvée soustrait dans une certaine mesure, à l'action des courants de marée se propageant moin librement entre le Stroombank et la côte. De là une tendance à envasemen dans cette partie de l'atterrage."

From this it would appear that the shoaling of the Petite Rad between the Stroombank and the coast-line was primarily th reason for cutting the eastern channel. With regard to St Catherine's Harbour, the Author had always understood that it wa abandoned by reason of a change of policy. Having had occasio to report a few years back upon the capabilities of a point on th Jersey coast contiguous to St. Catherine's for harbour purposes, he had noted that low-water line at St. Catherine's had been projected seaward, so that a length of more than three-fourths of the break-water was sanded up. Mr. Vernon-Harcourt's remarks as to Ceará were not quite inferential from the Paper, as the length of open viaduct in the structure bore so small a ratio to the length of the solid portion. Considering the existence of the Great Reef running parallel to the coast-line, it would appear, from what had taken place, that a shallow breakwater built upon this reef and connected with the shore by an open viaduct, would have been the true solution of the problem of Ceará. Mr. Voisin's remarks with regard to Boulogne and the data accompanying them were of great value. In reference to Mr. Wheeler's remarks, it was obvious from Mr. Bent's statement as to Ceará that not only did the drift pass directly through the viaduct, but it also passed round the end of the solid work. The two advancing waves of deposit left between them the pool shown in Fig. 22, Plate 4.

2 February, 1904.

Sir WILLIAM H. WHITE, K.C.B., D.Sc., LL.D., F.R.S., President, in the Chair.

The Council reported that they had recently transferred to the class of

Members.

Thomas Aitken.
Walter Bassett Basset.
Sydney George Brounger.
Harold Henry Lane Brown.
William Frederic Butler.
Walter John Fletcher.
Percy Tillson Gask.
Andrew Paton Gray.
Arthur Hoare.

And had admitted as

Students.

Cecil Lewis Fortescue, B.A. (*Cantab.*)
Arnold Frean Harrison, B.Sc. (*Victoria*)
George Walls Hilditch.
John Stevenson Young, B.Sc. (*Victoria*)
Thomas Adair Young.

The Scrutineers reported that the following Candidates had been duly elected as

An Honorary Member.

Viscount Kitchener of Khartoum, *Gen. R.E.*, G.C.B., G.C.M.G., O.M., D.C.L. (*Oxon.*), LL.D. (*Cantab.*)

Members.

Sir Robert Hanbury Brown, K.C.M.G., *Major* R.E. *ret.*
Charles Alfred Hasbrouck.
Frank Theodore Marshall.
Albert James Pringle.
William Rich.
Palmer Chamberlaine Ricketts.
John Joseph Welch.

Associate Members.

Robert Donald Thain Alexander, Stud. Inst. C.E.
Jules Edmond Barbier.
Frederick Grant Brighton, Stud. Inst. C.E.
Alfred William Burford.
Cecil Leonard Cartwright.
Edward Falk, Stud. Inst. C.E.
John Holliday.
Edward Clinton Jansen, Stud. Inst. C.E.
Eric Wilfred Kitchin, Stud. Inst. C.E.
Richard Smith Lea, Ma.E. (*McGill*)
Hastings FitzEdward Peet.
Richard Underdown Shaxby, B.A. (*Cantab.*), B.Sc. (*Lond.*), Stud. Inst. C.E.
John Reginald Taylor, B.A., Stud. Inst. C.E.
William Waters, Stud. Inst. C.E.
Charles Weekley, B.A. (*Cantab.*)

The discussion on Mr. A. E. Carey's Paper, "The Sanding-up of Tidal Harbours," occupied the evening.

Sect. II.—OTHER SELECTED PAPERS.

(*Paper No. 3434.*)

"A Practical Method of adjusting the Cables of Suspension-Bridges; with some Notes on Wire-rope Cables, Strands, and Anchorages, from recent Australian Practice."

By Ernest Macartney de Burgh, M. Inst. C.E.

There are few problems of greater importance in bridge-construction than that of adjusting the several members of the cables of a suspension-bridge so that the loading shall be equally distributed amongst them, while at the same time the required "dip" is obtained in the completed cable. The subject of unequal stressing due to mechanical defects in bridge-work has received a great deal of attention, it being generally admitted that the most careful calculations of the designer may to a certain extent be rendered useless by inaccuracies in the shop-work or on the part of the erecting engineers. A familiar instance is that of tension-members of pin-connected structures, where an error in the length of one link may lead to its being called upon to perform the work intended by the designer to be distributed over a group of links. The component parts of a suspension-bridge cable present a similar case, although they are vastly longer than the longest links, being indeed the longest tension-members used in any structural work.

Having occasion in 1895 to design and erect a suspension-bridge of 250 feet span for vehicular traffic over the Kangaroo River in New South Wales, the Author was impressed by the importance and difficulty of accurately erecting the cables. The design of the structure was a simple matter; the cable stresses were capable of exact determination, and each of the twenty-eight ropes was required to sustain a working load of 19·5 tons; but whether it did so or not, whether any individual rope was overstressed or idle, depended entirely upon its erected length. Special arrangements had been made in the anchorage-chambers of the bridge at considerable cost to adjust each rope to the correct length, but the problem of what was the correct length and how the adjustment was to be made remained to be solved. Available works of reference

gave no definite information on the subject; they were at one upon the point that the several members of a suspension-bridge cable should be erected so as to take the calculated load with the correct "dip" in the completed structure, but it appeared as if the method of obtaining the correct result was left to the erecting engineer, who, if successful in carrying out the intentions of the designer, was silent as to the means adopted to do so.

In the case of bridges of the first magnitude, such as Brooklyn Bridge, New York, where the wires forming the cables are assembled in place, special means are adopted to regulate the dip in each wire; and the vast number of wires so treated, and, no doubt, the friction between them when bound together, reduces the inequalities of stress to a minimum; but in the vast majority of suspension-bridges of 200 or 300 feet span, such as that referred to at the Kangaroo River, and even in structures of considerable magnitude, the wires are formed into ropes or strands, and these again into variously-arranged groups constituting the completed cable; and it is with this, the more usual type of cable, that the Author deals in the following Paper, although the system of adjustment described may also be found applicable to other types.[1]

Since the completion of the Kangaroo River Bridge the Author has had ample opportunity of testing the accuracy of the method of cable adjustment used there, not only for bridges of that size, but also in the case of small suspension footbridges of 150 to 250 feet span; but the Kangaroo River and Nepean River Bridges will be taken as illustrations affording good examples of grouped rope and grouped strand cables respectively, whilst the latter is an excellent example of how the anchorage arrangements may be simplified by the adoption of the method of cable adjustment about to be described.

Limit of Permissible Error in Adjustment.—The limit of permissible error may be dealt with under two heads, first, as it affects the "dip" in the cables, and second, as it affects the strength of the cables.

The Kangaroo River Bridge (Fig. 1, Plate 5) is a single suspended span of 252 feet 9 inches between the centres of the towers,

[1] In calling for competitive designs and tenders for the proposed bridge over Sydney Harbour in 1902, the Advisory Board (of which the Author is now a member) expressed a preference for cables formed on the Brooklyn system, of a mass of individual wires bound together parallel to one another, in the event of a suspension-bridge being adopted. The minimum span was fixed at 1,200 feet. A number of European firms, however, showed a preference for assembling the wires into ropes, or strands, and these again into groups to form the cables.

the cables having a dip of 19 feet 6 inches. The cables pass over saddles running on expansion-rollers on the tops of the towers, to fixed saddles at the tops of the anchorage-chambers, and thence vertically to the anchorage-girders, where each rope is attached to an adjusting screw, Figs. 2, Plate 5. Each cable (Figs. 3, Plate 5) consists of two groups of galvanized plough-steel wire-ropes, seven ropes to the group, seven strands to the rope, and seven wires to the strand, the centre strand being of mild steel. The ropes have a circumference of 4·41 inches, an average breaking-strength of 87·8 tons, a modulus of elasticity [1] of 25,000,000 lbs. (11,160 tons), and a weight of 20·75 lbs. per fathom (Appendix, Tables I. and III.).

The centres of the cables—the central point between the two groups forming a cable—are 25 feet 0⅝ inch apart at the centre of the span, 32 feet 10 inches at the tops of the towers, and 40 feet 2 inches at the anchor-saddles and at the anchor-girders. The cables being thus nearer each other at the centre of the span than at the towers by 7 feet 9⅜ inches, they lie in a plane inclined at an angle of 1 in 5 to the vertical; that is, in the same plane as the suspension-rods, whilst the major axis of each cable is normal to the suspension-rods, Fig. 3, Plate 5. If the cables while weighted were allowed to swing into the vertical plane, a position they must occupy during adjustment, they would show a greater dip—the true dip—in elevation, in this case 19·88 feet. In this case, with a dip of approximately one-thirteenth of the span, the curve of the cables in the completed work may, for practical purposes, be considered as an arc of a circle with a chord of 252·75 feet, a dip of 19·88 feet, and a length of 256·88 feet. Adding the estimated length of the cables between the towers and the anchorage attachments, the total length of the cable amounts to 446 feet. The camber in the suspended span should be sufficient to admit of deflection under live load, and at the same time lengthening of the cables under increased temperature, without sag; on the other hand, it must not be so great as to present an exaggerated appearance or

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[1] The modulus of elasticity here taken, and used throughout in calculating the extension of the ropes under loading, is not the modulus of the steel in tons per square inch, but the actual modulus of the complete rope. Owing to the centre strand in the rope being of milder steel than the six outer strands, the modulus of the latter does not apply accurately to the whole rope. Fourteen full-size specimens of these ropes were tested by Messrs. David Kirkaldy and Son, of London, and the modulus (25,000,000 lbs., or 11,160 tons) is calculated from the average of the actual extensions (0·16 inch) recorded upon a length of 100 inches under a load (40,000 lbs.) approximately equal to that which the ropes are worked to, namely, 19·50 tons.

to strain the connections in cold weather under the dead load only. In the case under review the camber was fixed at 9 inches at a mean temperature of 70° F. with dead load only. The stress on each rope due to dead load amounts to 12·22 tons, producing an elongation of 5·86 inches in the total length of the cable, and increasing the dip in a vertical plane from 19·88 feet to 21·01 feet, which, allowing for the plane of the cable being inclined to the vertical, gives a dip, as seen in elevation, of 20·64 feet instead of 19·50 feet. It is therefore evident that in setting up the cables allowance must be made for this elongation; otherwise, instead of a camber of 9 inches in the roadway, a sag of $4\frac{3}{4}$ inches will result, and that without any live load. Supposing the cables to have been adjusted and the bridge completed so as to have the required camber of 9 inches at 70° F., there remains the extension due to live load and increase of temperature to be allowed for. The stress on each rope due to live load amounts to 7·28 tons, causing an elongation of 3·49 inches in the total length of the cable, while a rise of temperature of 50 degrees, *i.e.*, from 70° F. to 120° F., in the sun will increase this elongation by 1·81 inch, or to 5·30 inches, and will result in an additional dip of $12\frac{1}{2}$ inches, entirely destroying the camber and leaving the bridge $3\frac{1}{2}$ inches low in the centre. This sag is not of serious importance in a highway-bridge where the full loading, combined with the maximum temperature, is not likely to obtain frequently, but it is clear that any additional sag due to error in the adjustment of the cables will give trouble. Every additional inch in the length of the cable is producing roughly $2\frac{1}{4}$ inches of dip, and if the required 9 inches of camber is not obtained, owing to faulty adjustment of the cables, a sag, which should only result under exceptional circumstances, will become of frequent occurrence under ordinary loading and temperatures. The Author has frequently heard it suggested that, so far as the camber in the completed bridge is concerned, no great care need be taken to obtain the correct dip in the cables, as the error can be rectified by adjusting the length of the suspension-rods; this is not so, for any attempted adjustment of the rods beyond the inch or so which they should legitimately deal with is certain to lead to distortion of the curve of the cable, and probably to cross strains in the rods near the centre of the bridge, owing to their leads being altered. Such practice is at best a slovenly method of correcting an error which should not exist.

With regard to the effect on the strength of the cables of errors in their adjustment, it is manifest that if any rope be longer than its fellows it will receive only a portion of the load it was designed

to take, and that portion will be less as the error in length increases. It has already been pointed out that when a very large number of small wires are tightly bound together the effect of errors of adjustment in individual wires is comparatively of small importance; but in a group of ropes clipped together any individual error in length must weaken the cable to an extent which is greatest if the slack is concentrated at one point—say between two clips—and least if it is evenly distributed along the length of the cable. In the example taken, the rope-load of 19·5 tons produces an elongation of 9·35 inches. Assuming that one rope is 9·35 inches too long, and that the slack is evenly distributed over the cable's length, it will do no work until the remaining six ropes of its group have extended 9·35 inches, at which time they will be carrying six-sevenths of the group-load, or 117 tons out of 136·5 tons. The remaining 19·5 tons will be carried equally by the seven ropes, the slack rope now coming into play, and the result will be that the group-load of 136·5 tons will be carried by six ropes taking 22·3 tons each and one rope taking 2·8 tons. An excess of 10·9 inches in the rope-length of 446 feet, or 1 in 491, will throw a rope out of work altogether, while a shortage will result in its being over-stressed. It may at first sight appear that such an error as 1 in 491 could not occur if the most ordinary care were exercised, but, for reasons which will be pointed out later, difficulties exist in making the necessary measurements and adjustments which admit of very considerable error, and, what is perhaps more important, leave the engineer in doubt as to the existence or amount of such error. Supposing that four ropes out of a group of seven are 4·67 inches longer than the remaining three—an error of 1 in 1146—they will not be stressed at all until the short ropes have elongated 4·67 inches, taking half the estimated load, or 29·25 tons, out of the group-load of 136·5 tons; the remaining 107·25 tons will be carried equally by all seven ropes, with the result that the three short ropes will take 25·07 tons each and the four long ropes 15·32 tons each. If instead of being distributed over the length of the cable the excess length in one or more of the ropes is confined to the space between two clips (which may occur), and if the clips hold the ropes so firmly as to cause them to act as one rope, a very small excess length will suffice to throw the slack ropes out of action. In the Kangaroo Bridge the maximum distance between adjacent clips is 6 feet 6 inches, and the extension of the cable under full load in that length is only 0·136 inch, while an error in length of 0·158 inch between the clips will suffice to throw a rope out of action. The

Author does not consider that clipping can be so effective as to produce these conditions, although if combined with binding it may do so to a considerable extent; it is quite certain, however, that the powerful clips used to attach suspension-rods to cables do concentrate errors of length in individual ropes in a comparatively small number of bays, that the error is more objectionable the more it is concentrated, and that clipping a number of ill-adjusted ropes firmly together will not make them into an effective cable. There is no doubt that error in the dip of a completed cable gives the erecting engineer the greatest trouble; it is at once evident in the levels of the deck, and is exceedingly difficult to correct, but need not necessarily affect the strength of the structure; on the other hand, error in the relative tension of the ropes, although really a more serious matter, may never be detected.

Ineffective Methods of Adjustment.—Probably the first method of erecting cables that suggests itself is to put each rope in position, and, having strained it to a certain extent to take out the effect of coiling, to observe the dip. It is only necessary to treat one rope in this way to be convinced that all attempts in this direction will be useless. Viewed in elevation the rope shows a smooth curve, but viewed from the top of the towers it will be seen to be a succession of waves, whilst a level will show that the lowest point of the curve is not clearly defined and may not be in the centre of the span. If a second rope be similarly erected it will be found that it does not lie close to the first; in fact, each rope has a characteristic wave, due to its "lay" and coiling, that can only be got rid of under a heavy load. Further, the weight of the centre span of rope is not sufficient to bring the portions between the towers and anchorages taut, so that a correction must be made for the dip to be taken up in these positions (and this is not easily ascertained) as well as for the actual extension under load of the rope itself. Even supposing these corrections made, the difficulty of accurately observing the dip, owing to the curve being flat and to the special characteristic or wave in each rope, will result in far greater error than is allowable.[1]

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[1] Referring to the difficulty of accurately observing the dip of the guide-wire which was used at East River on Brooklyn Bridge, Mr. Hildenbrand writes—"A successful regulation can only be accomplished in perfectly calm weather, and it requires therefore careful watching, sometimes for several weeks, until a favourable day offers itself. This was the case at East River Bridge, where for three weeks all attempts at regulating were fruitless." After each strand of two hundred and eighty-two No. 7-gauge wires was completed, it was regulated by a tangential observation of the "dip." "Instead of measuring this length,

Attention will next naturally turn to the measurement of the required length for each rope, and the measurement of the rope itself under sufficient stress to remove all waves. This is by no means a simple matter; the length of the curve-portion between the towers can be calculated, as also can that between the towers and anchorage-saddles, but some small and awkward measurements are required over the curved tower and anchorage-saddles, whilst the ropes, owing to their relative positions, are not of the same length. When the required length has been ascertained the measurement of the ropes involves a good deal of work, as each must be laid out at full length, supported at frequent intervals to eliminate sag, and subjected to sufficient strain to eliminate waves; and this requires a considerable space, which is not always conveniently available. If the rope so measured is then erected, there is no absolute certainty of accuracy, for there remains the possibility of error, first, in the measurement of the required length, and second, in making the ends fast, the latter being especially difficult to guard against.

In the first of these methods the adjusting anchorage-screws provided at the Kangaroo Bridge (Figs. 2, Plate 5) would be of service; but not in the second, where everything depends on making the rope fast at the exact measured distance. In neither case is there any check; the ropes must be taken to be correct as erected, and should there be any variation in the yield of the fastening, whether that be made by clipping round a "heart," as in the Kangaroo River Bridge, or by splicing, it is practically impossible to detect it. If the whole of the ropes are too long, or too short, the camber in the completed bridge will make the fact evident when it is too late to correct the error, for adjusting-screws will not work against the dead load of the bridge and the saddle friction combined, whilst it is practically impossible to detect an error in any individual rope by inspection.

A third method of erection, which the Author at first favoured, consists in fixing one end of the rope in its anchorage, and leading the rope over the towers to the other anchorage, where it is subjected to sufficient strain to eliminate waves. The length of the three curves formed by the rope being then calculated from their dip, is subtracted from the estimated correct length, and the difference is measured on the loose end and paid out. This lessens

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to do which accurately would be impossible, we establish again tangent-lines for the regulation, in the manner described for the guide-wire." "Cable-making for Suspension Bridges," Wilhelm Hildenbrand. Van Nostrands Series No. 32. New York.

the error in making fast by 50 per cent., as only one connection has to be made after measurement, and it eliminates the wave in the rope; but the observations and calculations leave ample room for error. In practice the Author takes great exception to each of these methods, and suggests the following as a more practical method.

Practical Method of Adjustment.—It has been shown that the error in dip is greater than the error in cable length producing it, and as it is the dip which is required to be accurate, it is the dip that ought to be measured, not the cable length. It has also been shown that the curve of a rope is not sufficiently defined to admit of accurate measurement of the dip by tangential observation, unless the rope is uniformly loaded so as to produce a fair curve free from wave, and to eliminate sag beyond the towers. While it is manifestly out of the question to apply such a uniform load during erection as would give the desired result, a central load can be used which will not only give a similar result, but will admit of the necessary measurements being made with great accuracy and with all possible sources of error eliminated.

This method was adopted at Kangaroo River Bridge, in the following manner:—The saddles on the towers having been wedged in a central position and greased, a rope was drawn into position, permanently fastened to its anchorage-bolt at one end, and temporarily to that at the other, care being taken that the temporary fastening was made in a similar manner to the permanent one. The rope was allowed to hang between the towers in a curve having a dip of a foot or two less than that required, but no care was taken to obtain a particular dip. A weight of 4·36 tons was placed in the bed of the river (which was dry at the time) under the centre of the rope, and, a snatch-block having been placed upon the rope, the weight was connected to it and lifted slightly off the ground. The effect of the weight of 4·36 tons was to draw the rope into a series of practically straight lines, under a stress of 12·22 tons (equal to that produced by the dead load), and to take up the slack in the fastenings and anchorages, as well as the sag beyond the towers, the waves in the rope, and the extension due to dead load. In order that the rope should be of the correct length, it was now only necessary that the portion of it forming two straight lines from the tops of the towers to the snatch-block in the centre should be equal to the calculated length of the curve in a vertical plane under the dead load, viz., 256·88 feet, or, in other words, that the centre of the rope should be 22·93 feet below its level at the top of the towers, Fig. 4, Plate 5. This, of course,

would not be the case on the first trial. It will therefore be supposed that the dip to the snatch-block was found on observation to be 1 foot too much, or 23·93 feet; the length of rope between the towers, as determined by calculation, would then be 257·24 feet as against 256·89 feet required, the rope being thus 0·35 foot too long. It would therefore only be necessary to release the weight, take up 0·35 foot on the rope, make the fastening permanent, and apply the central weight again as a check to complete the operation.

That this system of adjustment is capable of producing very accurate results is well shown by the foregoing example, the small error of 0·35 foot in the length of the rope producing a whole foot of dip, the error being multiplied by 3 at the point of observation. Indeed, the only reason for not getting the rope exact after the first trial is that some allowance has to be made for yield, or want of accuracy in making permanent the connection of the rope at the end which is temporarily fastened during the test. At Kangaroo River Bridge any small error found on second application of the weight was taken up by the tension-screws, but after experience had been gained in fixing the first two ropes it was not found necessary to move the screws more than about one thread, so little indeed that they might well have been dispensed with. There is a certain inaccuracy in assuming the several lines of rope under the action of the central weight to be straight lines; they are of course very flat curves; further the point of application of the weight is not a point, but a curve dependent upon the size of the sheave of the snatch-block used to suspend the weight. The Author has been unable to estimate the amount of these inaccuracies; they are inappreciable, and, being common to all the ropes, are of no account, especially as any sag in the ropes beyond the towers when under the adjusting-weight remains equally under the dead load in the completed bridge.

With regard to temperature, correction may be made by calculation, but the Author prefers to assume a temperature readily obtainable at some portion of the 24 hours, to fix the expansion-rollers, and to work to that temperature with each rope. A certain temperature may generally be relied upon to recur twice in each 24 hours, and it is better to wait for it than to test one rope in a very hot sun (when the temperature of the steel is really not known) and another in the cool of morning or evening, and attempt to bring them into line by calculation; indeed, it will be found better not to test ropes at all with the mid-day sun shining on them.

It is well here to sound a note of warning as to clipping together a group of ropes. It is an easy matter, even when all the ropes are of correct length, to clip one or more of them in such a way that they are thrown out of work, and it will be found an excellent precaution carefully to mark each rope at its centre, and at the centre of the towers, when under the adjusting-load; this will admit of the centre clips being accurately placed, and they may be firmly fixed; but the Author makes it a practice to loosen all clips after the complete erection of the bridge, to enable the ropes to take up the tension equally. Unless the dip of the cable is exceptionally great, the clips, even near the towers, will not slip.

A few details connected with the method of adjustment described in the foregoing may be briefly referred to. The curve length is the same for all the ropes, viz., 256·88 feet, but, owing to their grouping and to the inclination of the tower-saddles, each rope has a level dependent upon its position in the group; thus the centre rope in the inner group is 1·1 inch higher than the corresponding rope in the outer group, and so on. This is easily allowed for in observing the dip under the test-load. Again, while the two bottom ropes in each group rest entirely upon the grooves in the saddles (and will run freely upon them with the aid of a little grease) the two outer ropes rest partly on the saddles and partly on the adjoining ropes, while the centre rope and the two upper ropes do not touch the saddles at all, and some difficulty might be anticipated in getting them to slide. In practice the Author has found that the ropes slide freely upon one another if greased, but it is a simple matter to construct a skid of timber to fit on the saddle and take the place of the underlying ropes, and having a groove to take the rope which is being dealt with (Fig. 5, Plate 5), the ropes already adjusted being lifted out of place to make room for the skid.[1] A staff attached to the snatch-block will be found useful in observing the dip of the rope under the test-load, and convenient methods of marking the staff to suit differences of level in the

[1] In large bridges the ropes are sometimes kept separate from one another by distance-pieces, to facilitate painting; this results in a greater difference of level between the ropes over the towers, but otherwise does not affect the method of adjustment. In such cases also, it may be necessary to substitute a series of rollers for the saddle, to admit of the free movement of the rope over the towers during adjustment. The necessity for such special contrivances will depend upon the size of the rope and the pressure upon the tower; they are certainly not required in dealing with ropes and loads such as those described.

ropes, due to their position in the groups, will readily suggest themselves.

In dealing with cases in which the portions of the cables behind the towers support portions of the bridge the same method of adjustment is applicable, but the difference in length (calculated) between a straight line from the top of the tower to the anchorage-saddle and the length of the required curve must be added to the calculated length of rope to be drawn into the centre span by the test-weight; and lengths equal to this should be measured from the centres of the towers towards the central weight and accurately marked upon the rope while under test. If on the removal of the test-weight the ropes are then clipped with these marks over the centres of the tower-saddles the lengths will be correct for each span.

A Simple and Effective Anchorage-connection.—The anchorage-connections used in the Kangaroo River Bridge provided, at considerable cost, a means of adjustment which, in consequence of the method used to erect the cables, was not required. Moreover, the connection of the rope-ends by clipping them around the "hearts" provided a fastening which was difficult to make accurately, and which gave a varying yield under load. A fastening entirely free from yield is preferable, and such was adopted at the Harvey's Crossing Bridge, Nepean River, which was opened for traffic on 7 February, 1903. In this case the road descends a deep gorge by zigzags, and the natural features are such that it was impossible to obtain a length along the centre-line of the bridge which would admit of the road passing between the anchorages; consequently it had to enter from one side, under the cable, in curves ending at the towers of the main span. As the cliffs above the bridge afford an excellent anchorage in solid sandstone, the cables are carried on an upward gradient of 1 in 22·4 at one side and 1 in 11·9 at the other, from the tops of the towers into the cliffs instead of downwards as is usual, thus reducing the loading on, and consequently the cost of, the towers, and securing easily-drained anchorages, Fig. 6, Plate 5. The suspended span is 230 feet in length between the centres of the towers, the cables having a dip of 15 feet and a total length of 508 feet between the anchorages. In this bridge also fourteen ropes were used, in two groups of seven ropes each on either side of the bridge, each rope taking a working-load of 18·5 tons. Owing to the position of the anchorages the maximum thrust transmitted to the towers by the cables amounts to only 104·4 tons, and the line of pressure is not in the centre but strikes the base near the back

of the tower. Expansion is allowed for by hanging the tower-saddles on links, and the cables lie in one plane throughout, inclined at 1 in 5 to the vertical.

Tenders were invited for the supply of the ropes from one English and one German firm, the specification providing that each rope was to be a single "strand" in itself, formed of galvanized steel wires of about 0·160 inch in diameter, with a circumference of about 4 inches and a minimum breaking-strength of 80 tons. The exact diameter of the wires and their breaking strength were left to the manufacturers, as also was the diameter of the completed strand, the price being for the ropes required complete, not by weight. This specification has the advantage that, while it clearly indicates the class of rope wanted and ensures the requirements of the bridge being met, it leaves the details to the manufacturer, who is much better qualified than the engineer to judge of the exact quality of steel and diameter of wires which it will be most economical to adopt. With each strand two steel sockets were to be supplied, one fixed to an end of the strand and the other loose, to be fixed at the site.

The strands adopted, which were supplied by a German firm, had a centre- or soul-wire of mild steel, 0·190 inch in diameter, and six inner, twelve intermediate and eighteen outer wires, each 0·181 inch in diameter, the completed strand having a circumference of 4 inches, an ultimate tensile strength of 85·36 tons, an ultimate elongation of 6·87 per cent., a modulus of elasticity (calculated in the same way as for the ropes of the Kangaroo Valley Bridge) of 28,571,000 lbs. or 12,755 tons, and a weight of 20·16 lbs. per fathom (Appendix, Tables II. and III.). The anchorage-chambers (Figs. 7, Plate 5) consist of a cut, 3 feet in width, running 30 feet into the rock, and ending in a cross-cut into which the anchor-girders are solidly concreted, only sufficient space being left to admit of free access to the strands and sockets. The anchor-girders (Figs. 8, Plate 5) are formed of four steel rolled joists connected by plates to form one girder, and so arranged that a strand and socket complete can be inserted, socket first, through a central opening, and then moved to one side and secured in position by a steel locking-plate, which, together with the spacing of the steel joists, prevents the withdrawal of the socket. The total weight of the anchor-girder, locking-plates and sockets to secure fourteen strands is 2,737 lbs., being equivalent to 195·5 lbs. per strand, or 10·5 lbs. of steel for each ton of load secured, while in the Kangaroo River Bridge the anchorage-connections for fourteen ropes weighed 6,741 lbs., being equivalent to 481·5 lbs. per rope

or 24·7 lbs. of material for each ton of load secured; solid sandstone rock was available in each case.

In erecting the strands, the end on which the socket had been secured by the manufacturer was fixed in position in one anchorage and the other end was taken over the tower-saddles to the other anchorage and secured by a pair of powerful clips (Figs. 9, Plate 5) taking the place of the socket behind the anchor-girder, the free socket being kept on the bridge side of the anchor-girder. The test-weight was then applied, and the amount which the strand required taking up or paying out was marked upon it; the clips were then shifted for a final test, and the strand was marked accurately at the point where it would emerge at the back of the locking-plates. The Author had anticipated some difficulty in fixing the loose socket exactly at the mark upon the strand; but some trials made with spare sockets and short lengths of strand ordered for the purpose showed that they could be placed accurately in position to $\frac{1}{16}$ inch by the following method.

Method of Fixing the Sockets.—The strand having been marked at the back of the locking-plate, it was necessary that the bearing-surface of the socket should coincide exactly with that mark. The clips having been removed, the strand was withdrawn from the anchorage for convenience of working, and was cut off $7\frac{3}{4}$ inches beyond the mark, thus allowing 6 inches for the depth of the socket and $1\frac{1}{2}$ inch for the turned-in ends of the wires. To prevent the strand unlaying, it was neatly bound with wire for 2 inches below the mark, before being cut. When cut, the ends of the wires, $7\frac{3}{4}$ inches in length, beyond the binding were carefully straightened and each was bent back upon itself for $1\frac{1}{2}$ inch (Fig. 10, Plate 5). A useful tool which ensured all the wires being bent alike was made of a tapered steel bar bored axially to a depth of $1\frac{1}{2}$ inch and used as a lever. The ends of the wires were not tapered, as this does not appear to be necessary. The bunch of wires having been carefully cleaned with acid and tinned, the socket, which had already been tinned by the manufacturer, was drawn into place along the strand, considerable force being required to bring it up to the mark, where it was retained by fixing a clip behind it. The socket and wires were then brought to the necessary temperature, and sufficient Babbitt metal to fill the interstices between the wires was poured into the socket. It was intended to take up any error in the length of the cable by inserting slotted washers between the sockets and the locking-plates, but none were required, the length of the strands as adjusted by the method described being exact, and the camber of the completed span with full dead-load

being within ½ inch of the estimated camber. Indeed, after making certain allowances for variation of the actual weight from the estimated weight of the suspended span, and for temperature, no error was observable in the dip of the cable under the dead-load in the completed bridge. The socket employed (Fig. 11, Plate 5), having an internal taper of 1 in 4 (or 1 in 8 in the thickness of the metal), was also used in making the full-size tests of the strands, and in each case the strand broke clear of the fastening.

Comparison of Ropes and Strands.—The cables for these bridges afford an excellent opportunity of comparing the efficiency of the two methods adopted of assembling the wires, and the particulars for enabling such a comparison to be made are given in the Appendix, Tables I., II. and III. It will be seen that the weight and ultimate strength of the rope and of the strand are almost exactly the same, but the circumference of the rope is the greater by nearly ½ inch, although the wires used in the rope have a greater tensile strength (103·40 tons per square inch) than those used in the strand (94·24 tons per square inch); and to obtain this high tensile strength ductility has been sacrificed to a certain extent, the elongation being only 4·66 per cent. as against 6·87 per cent. in the strand. If therefore wire having an ultimate strength equal to that of the wire used in the rope were used in the strand also the cross-sectional area of the latter, and consequently its weight, would be reduced by 9 per cent.; the Author, however, prefers the milder wire used in the strand, unless reduction of weight is of special importance and results in material saving in cost. The ultimate strength of the rope is 87·81 tons as against 95·71 tons, the aggregate ultimate strength of its component wires, including the core—a loss in making-up of 7·9 tons, or 8·2 per cent.; whilst in the case of the strand the loss is only 3·64 tons, or 4·1 per cent. The large size of the rope compared with the strand is due to the percentage of voids being high, viz., 39·49 per cent., and to the large core necessary in such a rope. It has the disadvantage of exposing a larger surface to the atmosphere than the strand does, and that surface is more broken up and more difficult to paint.

The Author regrets that whilst fourteen full-size tests of the rope were specified and made, only two were specified for the strands. Mr. C. W. Darley, M. Inst. C.E., Inspecting Engineer to the New South Wales Government, had the specified tests of the strands carried out at Mülheim on Rhine, and an additional test with full records of the extensions under various loads, in England, making three tests in all. For ensuring the quality of

the strands being adequate to the requirements of the bridge, these tests, together with the exhaustive tests made of the wires, were sufficient; but they are hardly numerous enough for comparison with those of the ropes, which was not contemplated at the time. It will be seen from the Appendix, Table III., that the elongation under a load of 40,000 lbs. was 0·16 per cent. in the rope, and 0·14 per cent. in the strand; and that the moduli of elasticity, namely, 25,000,000 lbs. and 28,571,000 lbs., have been calculated from these extensions. It might be supposed that the modulus of elasticity of the strand would be lower than that of the rope throughout, on account of the milder steel used; but the Author takes the view that a smaller extension under the 40,000-lb. load might be looked for, having regard to the make-up of the strand, and to the wires settling into place to their work more quickly than those of the rope. Whilst this seems a reasonable assumption, it would of course be absurd to come to a conclusion upon the results of one test, more especially as some of the samples of rope tested gave as small extensions under the 40,000-lb. load, although the average extension was higher. However, upon the completion of the Nepean River Bridge, the cable extension under test-load demonstrated clearly that a modulus of elasticity of 28,571,000 lbs. was approximately correct for the strand. The Author would like to see some experiments made upon considerable lengths of strand and rope, in order to ascertain the effect of make-up and of lay upon the modulus for loads not exceeding, say, one-third of the ultimate strength; but, so far as the purposes of these notes are concerned, the chief point is, that whilst the modulus is important in determining the deflection of the bridge under loading, the method of adjustment described brings equal stresses upon all the members of the cable under the dead load, whatever the moduli may be. It would appear from this comparison that the strand is superior to the rope in every particular for cable work, and indeed it seems to compare very favourably with even the parallel-wire system, being certainly more convenient for ordinary suspension-bridges of the size of those described, and probably also for very much larger bridges limited only by considerations of manufacture and the weight of the coils for handling. In one respect the mild-steel strands were vastly superior to the ropes; in handling they uncoiled absolutely dead, were very flexible, and had very little characteristic wave, whereas the hard ropes were very obdurate.

It will be noted that galvanized wires were employed in both of these bridges; in the absence of tests before and after galvanizing the Author is not able to express an opinion as to the loss of

tensile strength, if any, due to the process, but would not suppose it to amount to much in the case of the mild-steel wire, although the process may have an annealing effect on the harder wire. This is a matter upon which the manufacturers' opinion would be of value, but it certainly appears that the protection afforded by galvanizing is well worth the extra cost when it is not intended to encase the cables, and even when casing is used, as a protection in travelling oversea and during erection.[1]

The bridges referred to were erected by the Public Works Department of New South Wales, and the description of them is communicated with the permission of the Under-Secretary.

In conclusion, the Author desires to acknowledge his indebtedness to Mr. James Rorison, Assistant Engineer, Public Works Department, N.S.W., who developed the system of adjustment described, and made the observations at both the Kangaroo River and Nepean River bridges.

The Paper is accompanied by a sheet of drawings, from which Plate 5 has been prepared; and by photographs of the bridges referred to, and the following Appendix.

[1] Since the Paper was written the Author has received a letter from the Inspecting Engineer (Mr. Darley) which contains the following in reference to this point:—"I made a few tests myself of the Black wire (for Harvey's Crossing Bridge strands) before galvanizing, and found that while the Black average breaking strength was 5,304 lbs., with 5·37 per cent. elongation in 10 inches, the galvanized gave an average of 5,391 lbs., with 7·07 per cent. elongation. This was a surprise to me, as I thought the galvanizing rather weakened the wire, but the manager (of the works) assured me that wire over about 12 to 15-gauge was improved by galvanizing when made of good steel."

[APPENDIX.

APPENDIX.

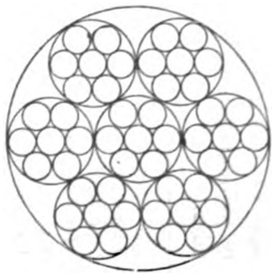
I.—COMPOSITION AND STRENGTH OF STEEL ROPES USED AT KANGAROO RIVER BRIDGE, FROM TESTS MADE OF INDIVIDUAL WIRES BY MESSRS. RYLAND BROTHERS.

6 strands of 7 wires.

1 core of 7 wires.

Weight per fathom, 20·75 lbs.

Cross-sectional area of steel, 60·51 per cent. of total area.



Diameter of wires before galvanizing, 0·156 inch.

Circumference of rope, 4·41 inches.

Lay, 1 turn in 18 inches.

Number of Rope.	Average Breaking Strength.		Equivalent Unital Stress.		Total Breaking Strength.	
	42 Outer Wires.	7 Core Wires.	Outer Wires.	Core Wires.	42 Outer Wires.	7 Core Wires.
	Lbs.	Lbs.	Tons per Square Inch.	Tons per Square Inch.	Tons.	Tons.
1	4,382	4,013	102·45	93·72	82·16	12·54
2	4,419	4,186	102·99	97·76	82·68	13·08
3	4,443	3,943	103·78	92·09	83·31	12·32
4	4,469	4,133	104·38	96·53	83·79	12·91
Average . .	4,428	4,068	103·40	95·02	83·00	12·71

Breaking strength of complete rope (from Table III.), 87·81 tons. Loss of strength in making up, 7·9 tons, or 8·2 per cent.

WIRES AT MÜLHEIM ON RHINE.

18 outer wires.

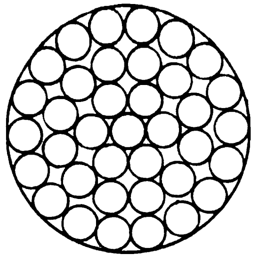
12 intermediate wires.

6 inner wires.

1 soul-wire.

Weight per fathom, 20·16 lbs.

Cross-sectional area of steel, 74·98 per cent. of total area.



Diameter, 36 outer wires, 0·181 inch.

Diameter of soul-wire, 0·190 inch.

Circumference of strand, 4·03 inches.

Lay, 1 turn in 12 inches.

Number of Strand.	Average Breaking Strength.		Equivalent Unital Stress.		Total Breaking Strength.	
	36 Outer Wires.	Soul-Wire.	Outer Wires.	Soul-Wire.	36 Outer Wires.	Soul-Wire.
	Lbs.	Lbs.	Tons per Square Inch.	Tons per Square Inch.	Tons.	Tons.
1	5,449	3,795	94·54	59·75	87·57	1·694
2	5.428	3,730	94·17	58·73	87·23	1·665
3	5,463	3,680	94·79	57·94	87·80	1·642
4	5,387	4,190	93·46	65·97	86·57	1·870
Average . .	5,432	3,849	94·24	60·59	87·29	1·718

Breaking strength of complete strand (from Table III.), 85·36 tons. Loss of strength in making up, 3·64 tons, or 4·1 per cent.

TABLE III.

RESULTS OF EXPERIMENTS TO ASCERTAIN THE TENSILE STRENGTH AND RATES OF EXTENSION OF STEEL WIRE ROPE FOR KANGAROO RIVER BRIDGE (TABLE I.), AND STEEL WIRE STRAND FOR NEPEAN RIVER BRIDGE (TABLE II.), BY MESSRS. DAVID KIRKALDY AND SON, LONDON.

—	Length of Test-Piece.	Loads in Pounds and Extension in Inches.									Ultimate Strength.		Ultimate Extension and Remarks.
		40,000	60,000	80,000	100,000	120,000	140,000	160,000	180,000	200,000	Pounds.	Tons.	
	Inches												
Kangaroo River Bridge: Rope. 6 strands of 7 wires; core, 7 wires	100	0·16	0·27	0·38	0·52	0·67	0·88	1·20	2·05	..	196,695	87·81	4·66 inches. These figures are the average of results from 11 samples tested.
Nepean River Bridge: Strand. 18 outer, 12 intermediate, 6 inner, and 1 centre wire	100	0·14	0·25	0·38	0·52	0·71	0·96	1·45	3·12	..	193,950	86·58	0·87 inches[1] One sample only tested in London; 2 samples tested at Mülheim on Rhine gave ultimate strengths of 82·8 tons and 80·7 tons. Average of three tests 83·36 tons.

The galvanizing was removed before testing. In the case of the rope broken with 82·8 tons at Mülheim on Rhine, one wire failed first, then another—pointing to uneven fastening. All ropes and strands broke clear of the fastenings. The fastenings of the strands were similar to those used in the bridge.

[1] Tests of 360 outer wires gave an average elongation of 7·16 per cent. Tests of 10 soul-wires gave an average elongation of 9·9 per cent.

(*Paper No. 3439.*)

"The Zifta Barrage and Subsidiary Works." ✓

By Frederick Arthur Hurley, Assoc. M. Inst. C.E.

The irrigation of the Egyptian Delta during the months of May, June, July and August has always been a difficult problem for the irrigation engineers in Egypt. The effects of the annual rise of the Nile in flood do not begin to be felt at Cairo until the end of June, and the volume of the discharge of the river is not sufficiently great to dispense with the necessity of regulation at the Delta barrage till about the middle of August in an average year.

During the months of May and June and the first fortnight or three weeks in July, the discharge of the Nile at Cairo, even in a summer of good supply, is not sufficient for the thorough irrigation of all the tracts under cultivation in the Delta; whilst during a summer of short supply the question of water-distribution becomes much more difficult. Restrictions have to be imposed upon the quality of the crops that may be sown, and the greatest care on the part of the irrigation officials is necessary in order to eke out the supply, to enforce the "rotation" regulations on canals and lifting-machines, and to ensure that the available water will be fairly distributed over the area under cultivation. This strain is most severely felt at the end of July and during the first weeks of August, when the demand for water suddenly increases and the first of the flood-water has arrived at Cairo but cannot be forced down the long lengths of canals in sufficient quantity to meet the demands of the cultivators. The reservoir at Assuan, by supplementing the natural discharge of the Nile during the months of May, June and July with the water stored during the first part of the year, will greatly relieve the strain and will provide a much better summer supply than has formerly been obtainable, but the reservoir cannot have any influence on the rise of the Nile flood, nor alter its date or character in any way.

The irrigation of the Egyptian Delta (*Fig. 1*) is divided into three natural divisions, viz.:—

(1) All the area to the east of the Damietta branch of the Nile (known in Egypt as "The First Circle of Irrigation").

(2) The districts between the Damietta and Rosetta branches of the Nile (known as "The Second Circle of Irrigation").

Fig. 1.

(3) The district to the west of the Rosetta branch of the Nile (known as "The Third Circle of Irrigation").

With the exception of flood feeder-canals, which only act during

floods, these "circles" receive all their irrigation-water from channels taking-off from the Nile, up-stream of the Delta barrage, about 12 miles north of Cairo, and the summer irrigation of the delta depends entirely on the level of water maintained up-stream of the Delta barrage. After the Nile flood begins to fall the Delta barrage keeps the water up-stream of it at such levels as are required to give the necessary discharge to the feeder-canals, the amount of water that is allowed to pass the Delta barrage gradually diminishing till about the middle or the end of April; all the regulating-gates are closely shut and caulked. All the available discharge of the Nile is then being forced into the "circle" feeder-canals, and the level up-stream of the Delta barrage gradually falls with the diminishing discharge of the Nile, till, about the middle or the end of June, the first effects of the approaching flood are felt.

The up-stream level then gradually rises till, about the end of July, it reaches the level of the tops of the gates, at 15·50 metres (50·85 feet) above sea-level. It is maintained at this level by gradually raising the gates as the flood-discharge increases, until all the gates are fully open; the subsequent rise above this level follows the natural rise of the Nile. A considerable discharge is therefore being sent down both branches of the Nile after the up-stream level of the Delta barrage has reached the level of the top of the gates, but at too low a level to be useful as a means of irrigation unless lifted by pumps. It thus happens that, from the end of July until such time as the gates are fully open and the up-stream gauge begins to rise with the rise of the river, which usually happens about the end of August, the discharge into the feeder-canals taking-off from the Nile up-stream of the Delta barrage cannot be increased, although a large quantity of water is running to waste down both branches of the Nile. The level maintained up-stream of the Delta barrage during the opening of the gates is about 80 centimetres (2 feet 7½ inches) below the level required to give full discharge to the feeder-canals, and even with the water at this level the feeder-canals are so long that it is very difficult, even by enforcing "rotation" regulations, to get the water down to the northern tracts of the Delta.

With the Zifta barrage at work, the water which is discharged down the Damietta branch of the Nile after the up-stream gauge at the Delta barrage has reached R.L. 15·50 metres (50·85 feet) will be dammed back and raised to R.L. 8·00 metres (26·25 feet) at Zifta, gradually rising to R.L. 9·00 metres (29·53 feet) as the river-discharge increases, and will be kept at this level by gradually

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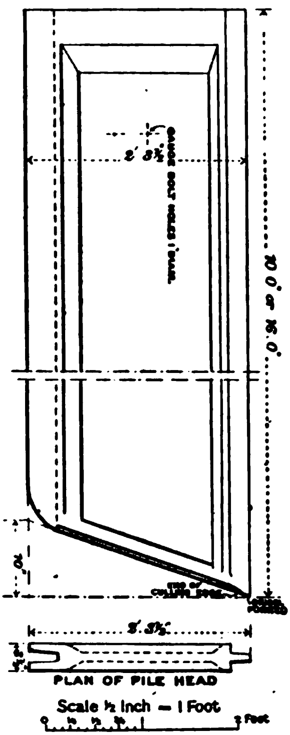
..s prepared by Mr. Willcocks, and provided for a barrage of ..one openings of 5 metres (16 feet 5 inches) each and a lock ..etres (39 feet 4 inches) wide, the floor of the work being at 3·00 (9·87) and the arch-springing at R.L. 13·00 (42·65). ..e level of the highest flood at Zifta is R.L. 12·00 (39·37) the ..one openings allowed for the maximum discharge of the ..etta branch of the Nile—4,687 cubic metres (165,500 cubic per second—with a velocity of 2 metres (6½ feet) per second ..ugh the openings. The design ..ly decided on was based upon new type of foundation intro..ed at Asyût, and included a lock ..metres (39 feet 4¼ inches) wide .. a barrage of fifty openings of ..etres (16 feet 5 inches) each, with ..tment-piers between each group ..en openings, Figs. 2, Plate 6.

The floor consists of a layer of con..te, 90 centimetres (3 feet) in thick..s, enclosed in a cofferdam of cast-.. sheet-piles of a special form, ..wn in *Figs. 2a.* The up-stream ..ain-piling is formed of piles 16 .. in length, and the piling on the ..wn-stream side, as well as the piling ..hind the lock abutment-wall and .. east abutment, of piles 10 feet in ..gth. On the concrete floor is laid ..10 metres (6·90 feet) thickness of ..ble masonry in cement mortar, ..he masonry being extended over the ..ops of the piles so as to afford facili..ies for dealing with any springs ..hat might occur between the con..te and the sheet-piling. On the ..tream side of the floor there is a clay apron 15 metres (49 .. width and 1·5 metre (4·90 feet) in thickness, protected ..ur by stone pitching; on the down-stream side there is ..rted filter-bed," likewise protected by pitching. On the .. formed are built the piers of the barrage and the lock- The piers are all 2 metres (6 feet 6¾ inches) in thickness, .. exception of the abutment-piers, which are 4 m.. 1½ inch) in thickness. The piers and the lock-wall..

Figs. 2a.



R.L. 5·00 (16·40) are built in brickwork in "homra" (or burnt clay) and lime-mortar, the noses and tails of the piers and the ends and corners of the lock-walls being faced with ashlar stone. The ornamental pier-caps and the copings to the parapets are of ashlar; the lock-walls and the wall of the east abutment are covered with an ashlar coping 30 centimetres (about 1 foot) in thickness. The top of the floor is at R.L. 3·00 (9·84) and the arch-springing is at R.L. 12·00 (39·37) the level of the highest known floods. The arches, 5 metres (16 feet 5 inches) span, have a rise of 1 metre (3 feet $3\frac{3}{8}$ inches) and are 60 centimetres (1 foot $11\frac{1}{2}$ inches) in thickness, backed up to the top of the crown with brick masonry. The roadway, consisting of a layer of concrete 25 centimetres (10 inches) in thickness and a layer of asphalt 5 centimetres (2 inches) in thickness, is carried on the arches and over the lock by means of a lift-bridge. Above the grooves of the regulating-gates the arch is split to allow of the gates being drawn up clear of the flood; and the two up-stream parapets that carry the winch for lifting the gates are at such a level as to permit of a 3-metre (10-foot) gate being housed clear of the maximum flood-level.

The up-stream parapets carry two powerful double crab-winches, capable of travelling from one end of the barrage to the other on rails laid on longitudinal sleepers, for raising and lowering the regulator-gates. The lock for navigation (Figs. 3, Plate 6) is 12 metres (39 feet $4\frac{1}{2}$ inches) in width and 65 metres (213 feet 3 inches) in length between the mitre-posts of the gates; it is provided with a masonry sill at R.L. 5·00 metres (16·40 feet) designed to prevent the entrance of silt into the lock-chamber, but the rest of the lock floor is at R.L. 3·00 metres (9·84 feet); the lock coping is at R.L. 13·00 metres (42·65 feet). The up-stream lock-gates are mounted on the masonry sill at R.L. 5·00 metres (16·40 feet), and the top of the gate sheeting is at R.L. 11·00 metres (36·08 feet), a platform at R.L. 13·00 metres (42·65 feet), carried on standards, facilitating the working of the winches; the down-stream lock-gates are mounted on the floor at R.L. 3·00 metres (9·84 feet).

It will be noticed that the top of the lock-gate sheeting is 1 metre (3 feet $3\frac{3}{8}$ inches) below the level of the highest flood, although above ordinary flood-level; but as during full flood the barrage and lock would be fully open and the lock-gates tied back in their recesses, the fact of the maximum flood overtopping the lock-gates is of no importance. The design of the lock-gates (Figs. 5, Plate 6) and of the opening- and closing-gear

used, is similar to that at the Asyût barrage. Each gate is opened by a chain attached to the sheeting about two-thirds of the way down from the top and at the middle of the gate's length; the chain is led from the gate under a guide-roller let into the masonry in the gate recess, up through a passage in the masonry, to the barrel of a hand-winch of ordinary design mounted on the lock coping. Closing of the gates is effected by a chain leading from the barrel of a separate winch, similar in design to the winch for the opening chain, down through a passage in the masonry and under a guide-roller let into the masonry opposite the top of the heel-post of the gates; the chain then passes round a guide-sheave mounted on the top pivot-pin, over suitable rollers to a vertical pulley at the centre-line of the gate-sheeting; it then passes down the front of the gate sheeting, under a sheave let into the bottom of the gate, and is attached to a lug on the cast-iron sill. The mitre-posts of the gates are of teak, but all the other parts of the gates that bear against the sills and quoins are of iron—that is, the "staunching," except at the mitre-post, is "iron to iron." The face of the cast-iron sill against which the bottom deck of the gate bears is planed to a true surface so as to bear truly against the gate, Figs. 6, Plate 6. The heel-post of the gate is of iron sheeting, semicircular in form. The hollow quoin is of cast-iron, with two staunching-strips carefully planed so as to bear truly against the heel-post of the gate when the gate is closed. The gate is mounted on a hemispherical-headed steel pin, the centre of the pin being placed eccentric to the centre of the heel-post, so that when the gate is shut and bearing against the cast-iron sill the heel-post fits tightly against the planed strips on the quoin; as soon as the gate begins to open the heel-post disengages from these planed surfaces.

Two regulator-gates (Figs. 4, Plate 6), each approximately 3 metres (9 feet 10 inches) in height, are provided for each opening of the barrage. The design for these gates is a copy of the usual design for regulator-gates used in Egypt, modified to suit the special conditions.

The grooves in which the gates move are of cast iron, and each gate is provided with four rollers which bear on a roller-path on the groove, and a staunching angle-bar, which, when the gate is down in position, engages on a planed staunching-strip on the grooves and makes a watertight closure. The gates work in separate grooves, and a staunching-strip of teak is attached to the upper gate so as to make a closure with the lower gate when both gates are down. The diameter of the barrels of the lifting-winch

is so arranged that when the gates are slung by the lifting-chains they are sufficiently clear of each other to allow one to pass the other without the timber staunching-piece fouling the rivet-heads on the lower gate. The gates are designed of sufficient strength to withstand the full head of water.

The crab-winches for lifting the gates travel on rails laid on longitudinal sleepers along the up-stream parapets, the axis of the winch barrels being vertically over the central web of the double grooves. Each gate is raised and lowered by two chains, one at each end of the gate; these chains engage on the winch on two separate barrels, mounted on the same axis and coupled together. The winch is provided with an automatic travelling-gear for slowly travelling the winch as the lifting-chains are wound on the barrel, so that the lift shall remain truly vertical. A hand-brake for quickly lowering the gates and a hand travelling-gear for rapidly changing the position of the winch are provided.

The roadway across the barrage is taken over the lock by a bascule-bridge. The roadway of the bridge is of timber supported on cross-girders. Cast-iron upright columns support cast-iron cross-beams, which support the counterbalance arms. The overhead arms are attached to the bridge by chains at their ends, and are furnished with counterbalance weights and lifting-chains at their opposite ends. The two halves of the bridge engage with a knuckle bearing, and are not fastened to each other in any way.

The excavation for the foundations of the lock-chamber was commenced on 3 March, 1901, and on 5 May the first cast-iron sheeting-pile was driven. The form of cast-iron pile used is similar to that employed at the Asyût barrage. The piles were driven with an ordinary pile-driving machine with a cast-iron monkey released by hand. All the joints between the cast-iron piles were grouted with neat cement so that the piles formed a thoroughly water-tight curtain. Concreting on the foundations of the lock was commenced on 19 May; the concrete used consisted of 5 parts by measure of broken stone, 3 parts of desert sand and 1 part of cement, laid in three layers of 30 centimetres (about 1 foot) thickness each, and well punned and watered. To ensure a watertight joint between the concrete and the face of the cast-iron piles the top of each layer of concrete alongside the piles was raked out to a depth of 10 centimetres (4 inches), and the channel thus formed was filled up with neat cement. Little trouble was experienced with the foundations, as at foundation-level a stratum of clay spread over most of the lock area and also over most of the regulator area taken in hand, although evidence was not wanting

that about 3 feet below the clay stratum there existed a sand stratum carrying water under considerable pressure. Several times strong springs carrying quantities of grey sand and smelling strongly of sulphuretted hydrogen burst up through the clay, and it often happened that similar springs came through the joints between the cast-iron piles during grouting operations. All the springs were, however, stopped without any special difficulty, and the draining of the area taken in hand was done by means of two 12-inch centrifugal pumps.

From the date of driving the first pile to the completion of the concrete of the season's work on 3 July, work was carried on incessantly night and day, the work being lit at night by fifteen electric arc-lamps. Night-work proved a great strain on the staff, but was, unfortunately, necessary in order to ensure the completion of the desired quantity of work before the arrival of the flood, at the end of July.

The laying of the rubble masonry of the floor was commenced on 21 May. The floor is of rubble stone laid in 3 to 1 cement mortar, all the stones being laid, as far as possible, with their longest dimensions vertical so as to obtain a vertical bond. The masonry was brought up rough to floor-level and was surfaced by laying fine concrete (composed of 2 parts of stone broken to pass a 1-inch ring, 1 part of sand, and 1 part of cement) between the projecting points of the rubble masonry. Any points of stones that projected above the theoretical level were dressed off with a stonedresser's hammer. No ashlar was employed on the floor. As only a very small quantity of bricks was ready during the first season, the lock above floor-level up to R.L. 5·00 metres (16·40 feet) was built in stone rubble-masonry in cement-mortar, and finished off with a belt-course of ashlar, above which the building would be in brick.

By 26 July the lock-foundation and superstructure up to 5 metres (16·4 feet) above foundation-level had been built, and the cast-iron sills for the gates had been fixed; a length of 71 metres (233 feet) of the regulator-floor, 3 metres (10 feet) in thickness, had also been built, with the pier bases of seven piers up to 1·60 metres (5·25 feet) above floor-level. On 27 July the rising Nile topped the "sudds" and brought all work for the season to a close.

The execution of this first season's work rendered the carrying out of the programme to finish the barrage early in 1903 practically a certainty. The seven openings would be sufficient waterway for the reduced Nile discharge during 1902, and the whole

remaining foundation-area could be dried and attacked at one operation.

At the end of November the Nile was lowered considerably by regulation at the Delta barrage, and the excavation for the foundation of the east abutment was commenced. The Nile bank on the west side was cut open to allow of the railway-line being relaid; and preparations were made for constructing a temporary railway-bridge down-stream of the permanent work already constructed. The construction of sudds was commenced on 10 December. A sudd made of sacks filled with earth was laid across the finished floor, in a line with the seventh pier from the lock. Two sudds of earth were pushed out from the east bank to meet the cross sudd and enclose all the foundation-area. As the closing of the sudds would force all the Nile discharge through the seven regulator-openings already constructed, at a high velocity and raised level, the lock walls and the seven piers were at once built up to 3 metres (10 feet) above floor-level, so that they should be "set" and hard before the water was turned through the openings.

The building of the lock walls proceeded slowly till they were finished up to R.L. 11·00 metres (36·08 feet); at this point the building was stopped and was not recommenced till the lock-gates had been slung. The sudds were closed with considerable difficulty on 1 January, 1902. A temporary railway-bridge, consisting of steel girders supported on wooden trestles and floored over for foot-traffic, had been completed on 24 December. Railway-lines were laid down on the sudds for transport of materials, and temporary pumps were installed to pump the water out of the space enclosed by the sudds. Two 8-inch centrifugal pumps were sufficient to lower the water inside the sudds and to enable pumps to be placed on four stages; these stages had been prepared, and pumping-wells had been sunk, during the 1901 season's work, and had been submerged by the flood; by 20 January all the pumps were fixed and working. Three 12-inch pumps and one 10-inch pump were found sufficient to drain all the work to foundation-level. The excavation proceeded rapidly, care being taken that the work was carried to a low level at the east abutment, at the end of the 1901 season's work, so as to enable pile-driving operations to be commenced at the earliest possible date. The foundations proved exceptionally dry, the black clay stratum found during the 1901 season spreading over most of the area. At the east abutment, however, the clay suddenly stopped and the foundation was of

ing sand and mud, which was excessively troublesome during driving of the cast-iron piles, as the timbers supporting the kept constantly sinking and getting out of line; the laying concrete over this area was also a matter of considerable ulty. The driving of the cast-iron piles was commenced at t abutment on 7 February, and at the west side (to continue iling of the 1901 season) on 14 February. Six pile-driving ines were used, three on the east side and three on the west the machines working from west to east and from east to o as to meet somewhere near the centre of the season's Each machine was in charge of an experienced English river; these men were specially selected and sent out through rtesy of Messrs. J. Aird and Company. The concrete and masonry of the floor was similar to that laid during the ason's work. All the foundations up to floor-level were at the end of April 1902. Very little difficulty was nced with springs; some strong springs occurred on the be covered with concrete, but as they all came through in the clay stratum they were easily localized, forced into itted with "T-piece" escapes, and finally stopped by being d up with cement grout under pressure. The piers built on or were constructed of brick in mortar of "homra" and lime, s and tails of the piers being faced with ashlar stone. All rstructure above floor-level on the barrage and above R.L. etres (16·40 feet) on the lock is built of bricks with " and lime mortar.

ra" is practically brick-dust; it is manufactured by clay balls in the same manner as in brick-making, except balls should be rather underburnt. The balls, after aken from the kiln, are ground in a disintegrator to neness that the resulting powder shall pass through a 2-millimetre (0·078 inch) mesh. The burnt clay wes its local name to its colour, "homra" being the ord for "red." All the homra used on the works was he brickyards of the works. The lime used was burnt om a limestone brought from the quarries at Tourah, Mortar is made from homra and lime by mixing ra with 3 parts of lime and grinding the mixture a mortar-mill of the ordinary type. The result- excellent, and makes a very watertight joint; it res careful handling to obtain the best results, nce in the setting-qualities of mortar mixe the ingredients are themselves good, and

well ground and mixed in mills with heavy rollers, is very marked.

By the end of July, when the flood arrived, the building of the piers was complete up to the springing of the arches; the lock-walls and the east abutment-wall were complete up to R.L. 11·00 (36·08), and all the pitching at floor-level and the revetments up to ordinary flood-level were finished. Owing to delay in the delivery of the ironwork for the lock-gates, the lock-chamber had to be kept dry till the middle of August, when the lock-gate had been erected and slung in position. The work was completely finished on 4 March, 1903.

Rayah Abbas Head.

The head-regulator for the new canal to feed the districts lying to the west of the Zifta barrage consists of a regulator of four openings, each 5 metres (16 feet 5 inches) wide, and a lock 8 metres (26 feet 3 inches) in width and 35 metres (115 feet) in length between the mitre-posts of the lock-gates, Figs. 7, Plate 7. The design for the head-work is practically the same as that for the Zifta barrage. As, however, it might happen in some summers that the water in the Nile might be at a lower level than the water in the canal, the regulator is designed to resist water-pressure from both directions. The piers and foundations are strong enough to resist a full head of water from either direction, the regulator-gates are capable of making a tight closure when the water-pressure is from the canal side, and the lock is fitted with a double set of lock-gates. The floor consists of a layer of concrete 90 centimetres (3 feet) in thickness, composed of broken stone and lime-and-homra mortar, and 1·60 metre (5 feet 3 inches) thickness of rubble masonry, also in lime-and-homra mortar, the top of the floor being finished off in the same manner as the floor of the Zifta barrage. The design allowed for a curtain of cast-iron sheet-piling all round the foundations, but, as the foundation proved to be of hard clay, only an up-stream curtain of 16-foot piling was considered necessary. A clay apron, protected by dry rubble pitching, is laid both up-stream and down-stream of the floor, with inverted filter-beds beyond the clay aprons. The design of the superstructure is the same as that of the barrage, and the two works are connected by a continuous revetment. Each opening of the regulator is fitted with two regulating-gates, each 3 metres (9 feet 10 inches) in height, raised and lowered by a travelling crab-winch of the same design as those on the barrage. The lock is spanned by a lift-

bridge of the same type as that designed for the barrage. The gates for the lock are sheeted to the top, as they may be required to hold water in highest flood; they are opened and closed by a compensating-chain and a push-bar gear; the gear used on the barrage is better for single gates, but becomes too complicated for convenient use when a double set of lock-gates is employed.

The excavation for the foundations was commenced on 3 April, 1902, and the building, up to floor-level, was finished at the end of June, 1902. Work on the regulator suffered delays from the same causes that affected work on the barrage—cholera followed by winter weather—but the whole building was completed on 20 February, 1903.

Rayah Abbas.

The preliminary surveys and levels for the canal were made during the autumn of 1901. The line finally decided on ran from a point about 200 metres (220 yards) up-stream of the Zifta barrage in a north-westerly direction, to connect with the Bahr Shebin near a village called Mit-Meymoun. As the canal was required to carry a discharge of 10 million cubic metres (353 million cubic feet) per day with a surface-level not exceeding R.L. 9 metres (29·52 feet) in flood, and a possible summer discharge of 5 million cubic metres (176½ million cubic feet) per day, with a level not exceeding R.L. 6 metres (19·68 feet), the canal was designed with a width of bed of 25 metres (82 feet), the side slopes of the cut being 1 to 1. The reduced level of the bed at the intake is R.L. 4·5 metres (14·76 feet), and the bed has a longitudinal slope of 1 in 10,000. The type-section of the canal and a longitudinal section of the country traversed are shown in Figs. 8 and 9, Plate 7.

The masonry works on the lines consisted of siphons to pass the existing canals under the new cut, two siphons under the new cut for projected drains, a flood-escape for one of the high-level canals (Bahr Shershabeh) into the Rayah Abbas, and an iron swing-bridge on masonry supports to carry the Delta Light Railway Company's line over the new canal. These works were commenced in April, 1902, and, with the exception of a siphon for the Omar Bey canal, were finished in December of the same year. The type of siphon built is illustrated in Figs. 10, Plate 7. The bridge for the Delta Light Railway consisted of one fixed span and a double swing-span, supported on masonry piles and abutments. The iron-work for the bridge was supplied and erected by Messrs. Ransomes and Rapier.

No difficulty was experienced with any of these works except

the siphon at Omar Bey; the foundation there proved exceptionally bad, consisting of fine running sand and mud mixed, and numerous springs. Two 12-inch pumps were required to drain the work, and it was not until 15 January, 1903, that the concrete foundation was laid and the iron pipes placed in position. The siphon was completely finished on 8 February.

The excavation of the canal was commenced during August, 1902, and was completely finished on 1 March, 1903.

The cost of the works, including the cost of acquiring the necessary land, is approximately:—

—	Work.	Land.	Total.
	£	£	£
Zifta Barrage	282,900	3,434	286,334
Rayah Abbas Head	46,637	..	46,637
Rayah Abbas	34,827	17,903	52,730
Works on line of Rayah Abbas	14,132	..	14,132
Total	..	..	£399,833

Water was admitted into the canal on 1 March, 1903, from the Bahr Shebin, and on 4 March the regulating-gates of the barrage were dropped and the up-stream level was raised to R.L. 6 metres (19·68 feet). On 7 March, 1903, the last stone to complete the barrage was laid by His Highness the Khedive in the presence of Lord Cromer, H.E. The Minister of Public Works, and other ministers, officials, and guests. His Highness subsequently declared the canal open and named it the "Rayah Abbas."

The Author had charge of the work under Sir Hanbury Brown, K.C.M.G., the Inspector-General of Irrigation. The staff employed was not a large one, and in spite of the fact that most of the executive staff were unacquainted with the execution of large public works and that the clerical staff had to be specially trained, their duties were carried out in a perfectly satisfactory manner and with an energy which resulted in the quick completion of the work.

The Paper is accompanied by fourteen tracings, from which Plates 6 and 7, and the Figures in the text have been prepared, and by two photographs which may be seen in the library of the Institution.

(*Paper No. 3464.*)

"The Effects of Annealing on Steel Rails."

By Thomas Andrews, F.R.S., M. Inst. C.E., and
Charles Reginald Andrews.

In an Appendix[1] to the Report of the Committee appointed by the Board of Trade to enquire into "The Loss of Strength in Steel Rails through use on Railways," published in 1900, the statement is made that "It appears probable that a great improvement might be effected by reheating the finished rail after rolling." The Authors have made experiments in this direction, and the results, given in the following Paper, show the effects produced by annealing, and also afford some indication of the physical effects produced by heating steel rails when shaping them in connection with various permanent-way arrangements.

For these experiments new steel rails, of sections usually employed on main lines, were selected from those supplied in bulk by several of the best English makers, the rails selected being taken at random from various lots supplied during a period extending over the last 5 years. Most of the rails examined weighed 85 lbs. per yard; the remainder weighed about 92 lbs. per yard.

The experiments were divided into seven sets :—

Set 1. Effect of annealing steel rails at a temperature of 770° C.—Six samples of medium-carbon and medium-manganese steel rails, and an equal number of high-carbon and high-manganese steel rails, were tested together and the results compared. Each sample consisted of a 14-inch length of rail. The normal chemical analyses of the rails before annealing, and the results of the physical tests, are given in Appendix I.

The samples were tested for their normal physical properties in the unannealed condition as received from the makers. They

[1] Appendix XI., "Notes on the evidence afforded by the Chemical and Micrographical Examination of Steel Rails." By Sir W. C. Roberts-Austen and Dr. T. E. Thorpe, p. 110.

were then cut into halves, and twelve halves, one from each sample, were annealed together in a furnace of large capacity, capable of containing more than 30 tons. The rails were placed in a suitable position in the furnace and were covered with powdered lime. The terminal of a platinum-rhodium thermopile was inserted in the centre of the group of rails, none of which were in direct contact with one another. Connection was made with a Le Chatelier self-recording pyrometer, and the record of the annealing temperature employed is shown in *Fig. 1.* A period of 25 hours was required to reach the maximum temperature of 770° C., and subsequently an additional 72 hours was needed for the rails to arrive at the normal atmospheric temperature. The rails were then withdrawn and machined for the comparative physical tests, the results of which are given in Appendix I.

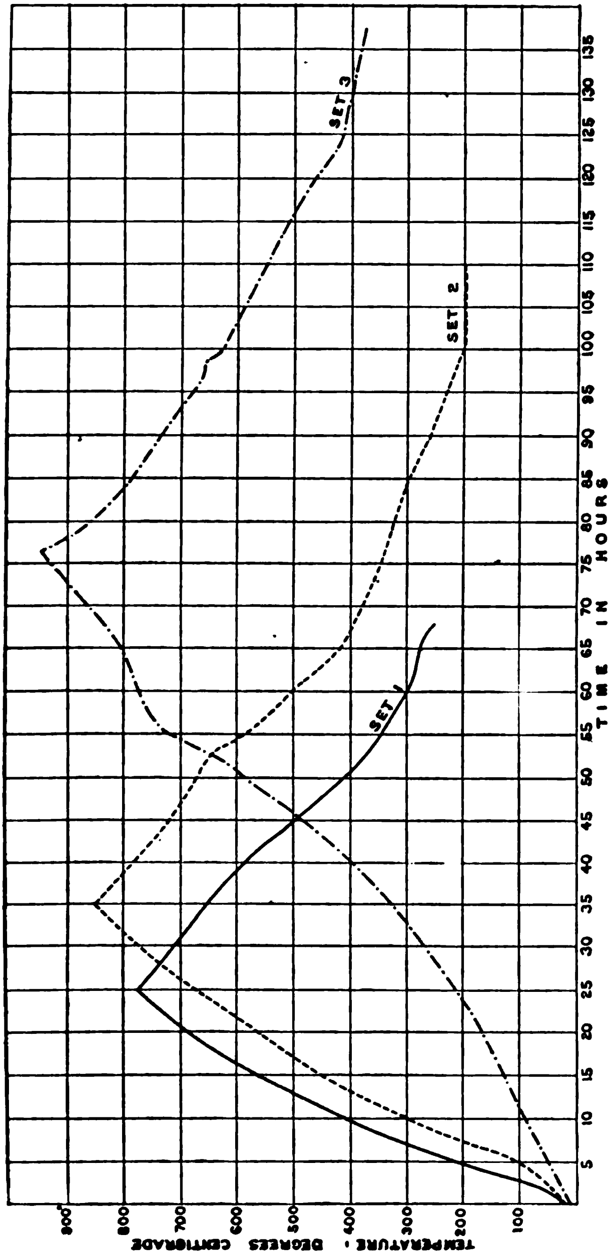
Set 2. Effect of annealing steel rails at a temperature of 850° C.—The experiments were similar in every respect to those of Set 1, except that the annealing temperature employed was 850° C. The normal chemical analyses of the rails, and the results of the physical tests, are given in Appendix II., and the record of the annealing temperature is shown in *Fig. 1.*

Set 3. Effect of annealing steel rails at a temperature of 940° C.—The experiments were similar to those of Sets 1 and 2, the annealing temperature employed being 940° C. The normal chemical composition of the rails and the comparative results of the physical tests, before and after annealing, are given in Appendix III., and the record of the annealing temperature is shown in *Fig. 1.*

Set 4. Loss in weight and in size, due to annealing.—This part of the investigation was undertaken in order to determine the loss in weight and in linear dimensions, of steel rails, from oxidation or scaling during the process of annealing. The annealing temperatures employed were 850° C. and 940° C., and in each case six medium-carbon and medium-manganese rails were compared with six high-carbon and high-manganese rails. The results of the observations are given in Appendix IV. These results indicate generally that the loss from oxidation during annealing is somewhat greater in rails containing high percentages of carbon and manganese than in rails containing medium percentages of these elements.

Set 5. Effect of annealing on the chemical composition of steel rails.—Analyses of each sample of rails were made before annealing; and after the annealing one sample was selected as being typical of medium-carbon and medium manganese rails, and two samples as

Fig. 1.



Curves showing Annealing-Temperatures employed in Experiments, Sets 1, 2 and 3.

representing high-carbon and high-manganese rails. The comparative analyses of these specimens before and after annealing at a temperature of 850° C., are given in Appendix V. It will be seen that the general chemical composition of the rails has not, in the mass, been very materially affected, although the carbon contents appear rather higher in the annealed than in the unannealed specimens.

Efficient annealing at a suitable temperature is calculated to improve the general physical properties of most steels used in engineering construction, especially of large steel forgings and steel castings; but excessive annealing should be avoided, as there is possible risk of damaging the physical structure. Annealing generally produces a more uniform structure throughout the mass, and, under proper thermal conditions, it results in a reconstructed micro-crystalline formation of the metal, free from the lattice-like aspect, as seen in microscopic sections, generally typical of ingot structure, which, if remaining in finished constructions of steel, undoubtedly constitutes a source of local weakness. In these experiments the annealing of steel rails has generally resulted in an improved crystalline and physical structure, but whether the altered physical properties have made the rails more durable for main-line service, cannot be definitely ascertained without practical trial on a large scale on the permanent track. If the practical difficulties of dealing, in the process of annealing, with such large quantities of steel rails as are daily turned out could be overcome, it is very probable that a more uniform general structure of rails would result from annealing, but other practical difficulties arise in connection with annealing which will be referred to later.

Set 6. Effect of annealing on the hardness of steel rails.—Selections were made for a comparative series of experiments from a number of typical medium-carbon and medium-manganese steel rails, and from an equal number of high-carbon and high-manganese steel rails. The chemical composition and physical properties of the rails used in the experiments are given in Appendixes II., III. and V. Test-pieces 6¼ inches in length by ½ inch square were accurately machined from the bottom of each rail, the longitudinal faces being carefully polished. The rail-bottom was selected as affording a more regular physical structure than generally obtains in the rail-head. (This one of the Authors has previously demonstrated experimentally.) Each test-piece was then subjected, in a testing-machine, to regular increments of pressure from an exceedingly fine knife-edge, forming the angle or corner of a bar 1½ inch square, of specially hardened and polished steel,

and the comparative indentation produced was observed, readings being taken to $\frac{1}{1000}$ inch. Three indentations were made on each sample at distances of 2 inches apart longitudinally, and the average depth of the indentation was recorded. This method was adopted in order to obtain results comparable with those recorded in the Report [1] of the Royal Commission on "The Loss of Strength in Steel Rails through use on Railways." The Authors, however, considered it essential to employ a longer test-piece than that used in the experiments of the Royal Commission. The relative hardness-numbers were obtained by the method adopted by Professor W. C. Unwin, F.R.S., in the above-mentioned Report, by the equation

$$p = c\,i$$

p being the load per inch width of knife-edge in tons, and

i representing the corresponding indentation in inches.

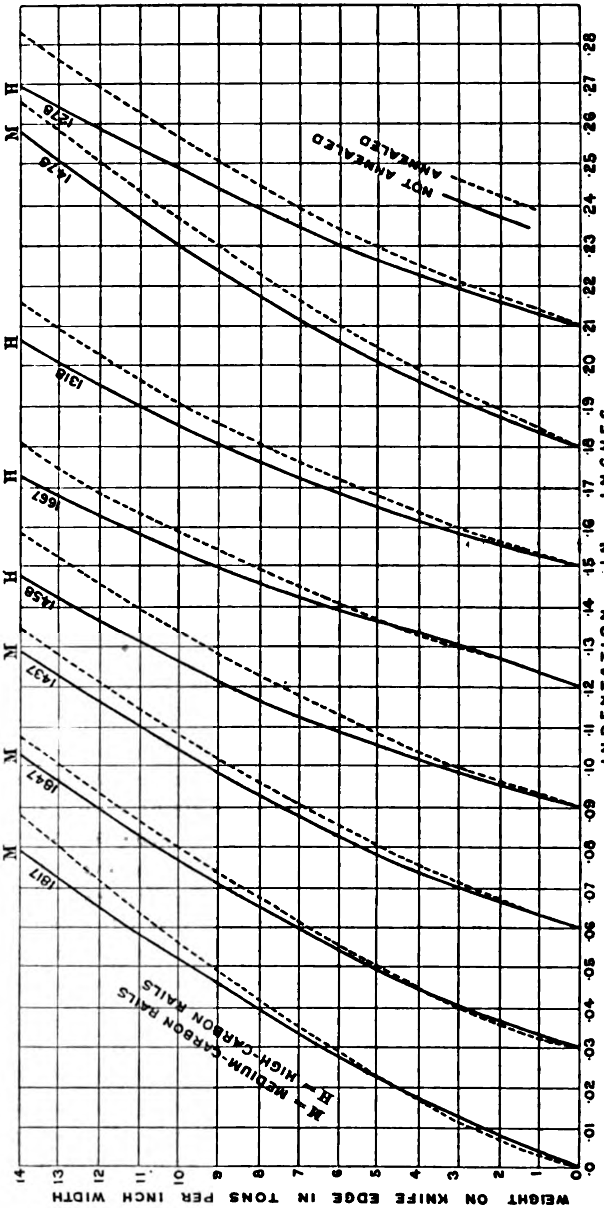
In this method there is, however, a certain liability to error from the shearing action of the knife-edge after the first indentations, and yet it would be unwise to rely on an estimate of the hardness-numbers from the earlier readings of the indentations. Before testing, accurate gauge-points were marked upon the bar, towards the ends. After the three indentations had been made, the piece was found to have elongated between the gauge-points on the top side, where cut by the knife-edge, to the extent of 0·33 per cent., whilst on the underside of the test-piece the elongation produced by the indentation of the knife-edge was only about 0·16 per cent., as measured between the gauge-points, and in some cases the elongation on the underside of the test-pieces was almost imperceptible. Variations in hardness to some extent were also observed within distances of 4 inches, and sometimes even within distances of 2 inches, in the length of the rail. The comparative results of the total extent of the indentations appear also to be capable of affording some indication of the relative plasticity of the steels. The results of the hardness tests are given in Appendix VI. The relative effects of annealing on the hardness of medium-carbon and medium-manganese steel rails, as compared with high-carbon and high-manganese steel rails, under the varied thermal conditions described, are illustrated in *Fig. 2*.

A comparison of the results given in Appendix VI. shows that the hardness of the normal unannealed medium-carbon and medium-manganese steel rails was, on an average, about 24·26 per

[1] p. 30.

cent. less than that of the normal unannealed high-carbon and

Fig. 2.



CURVES SHOWING RESULTS OF HARDNESS-TESTS.

high-manganese steel rails. On comparing the relative hardness

numbers of the same rail before and after annealing, it will be seen that in the case of the medium-carbon and medium-manganese steel rails, on annealing at 850° C., the hardness was reduced by about 6·74 per cent., and on annealing at 940° C., by about 14·07 per cent.; whilst in the case of the high-carbon and high-manganese steel rails, the reductions were respectively about 13·06 per cent. and 18·13 per cent. This indicates that the chemical composition of the rails had considerably affected the influences of annealing.

The results therefore indicate that the reduction in hardness, due to annealing at a temperature of 940° C., is greater than that due to annealing at 850° C., and at either temperature the effect is more marked in the case of the high-carbon and high-manganese steel rails.

Set 7. Effect of Annealing on the Crystalline Structure of Steel Rails.—Suitable portions were cut from a number of normal unannealed steel rails, and machined for longitudinal micro-sections near the rail-face. Some were typical of medium-carbon and medium-manganese steel rails, and others of high-carbon and high-manganese steel rails of the chemical composition and physical properties given in Appendixes II. and V. Similar micro-sections were prepared from the same rails, close to the same position, after having been annealed at a temperature of 850° C. The whole series of micro-sections were etched, each for the same period, in very dilute nitric acid of suitable strength, to develop the micro-structure, and they were carefully examined at various magnifications in order to investigate any possible alterations of micro-crystalline structure resulting from the annealing.

Seventeen photo-micrographs were taken at a magnification of 250 diameters, and of these Figs. 3, 4, 5 and 6, Plate 8, are typical, as showing the micro-crystalline structure, as seen in section, of normal unannealed steel rails, compared with the structure of the same rails annealed under the conditions stated. The rails shown in Figs. 3, 4, 5 and 6, Plate 8, were of the chemical composition and physical properties given in Appendixes II. and V.

It was noticed that the etched figures of the carbide of iron areas, or "pearlite" crystalline grains, were generally larger and more irregular in form in the annealed samples than in the unannealed, and the somewhat sharp angular crystalline structure of some of the etched figures of the carbide of iron grains, or areas was less defined in the annealed than in the unannealed rails. the annealed rails the crystalline formation appeared to be of

more intertwining and interlocking nature than was the case with some of the unannealed rails.

The general type of crystalline structure of normal unannealed medium-carbon and medium-manganese steel rails is shown by Fig. 3, Plate 8; it will be seen that the carbide of iron areas are evenly distributed throughout the mass of the ferrite, or pure iron, portion of the steel, a formation characteristic of this class of rails. This crystalline structure yields excellent results in respect of durability and safety in rail service.

The micro-crystalline formation of a normal unannealed high-carbon and high-manganese steel rail is shown in Fig. 5, Plate 8. It will be seen that, as compared with the medium-carbon and medium-manganese steel rail, the high-carbon and high-manganese steel rail exhibits a comparatively uneven general structure and disproportionate distribution of the carbide of iron areas, these areas being generally of a larger type and frequently appearing to run into one another. This segregated formation appears to be more liable to develop lines of transverse weakness than that of the structure of medium-carbon and medium-manganese steel rails. One of the Authors has had considerable practical proof of this danger in the cases of fracture of high-carbon and high-manganese steel rails which he has examined, and which have recently occurred in main-line service on some of the chief English railways.

In the high-carbon and high-manganese steel rails, after annealing, the etched figures of the carbide of iron or pearlite areas appeared to be segregated together in larger groups than in the medium-carbon and medium-manganese steel rails. A noticeable alteration of the general micro-crystalline structure had apparently resulted from the annealing, sufficient to account for the alteration in the physical properties recorded in Appendix II. These changes would probably be more marked in those rails which had been annealed at the higher temperature of 940° C., as in that set of observations the diversity of physical structure between annealed and unannealed rails was generally more apparent (Appendix III.). In some instances the long longitudinal lines of "ferrite" as seen in section at high magnification, in some places in the unannealed high-carbon and high-manganese rails, were still visible in the annealed samples.

In Fig. 6, Plate 8, will be seen elongated streaks of ferrite running at an angle of 45° across the rail-face; such a structure would in all probability develop a fine transverse crack on the face of the rail under the vibratory stress of main-line wear. The Author has noticed many instances of the development of these

fine transverse cracks in actual practice. In Fig. 5, Plate 8, will be seen a streak of ferrite running longitudinally along the rail-face, as seen in section, and having a sharply-defined and distinct crystalline structure from that on either side of it; in fact, the ferrite streak practically cuts in two the general adjacent crystalline formation. Conditions of this character frequently develop longitudinal fissures on the face of rails after only a short period of wear, and as longitudinal flaws almost invariably develop transverse ones, striking off by means of various ramifications at various angles from them, it will be seen that such a crystalline formation is inimical to durability and safety in rail service. One of the Authors has recently examined a rail, which fractured after only a comparatively short main-line life, in which this particular structure was very markedly developed.

In some places, in the high-carbon and high-manganese steel rails, the micro-flaws or "blebs" of sulphide of manganese or other impurity had locally segregated, as shown in Fig. 5, Plate 8; the medium-carbon and medium-manganese steel rails, both in the annealed and in the unannealed condition, were comparatively free from conditions of local weakness of this nature. Another noticeable result of the microscopical investigation was the appearance, after etching, in the annealed samples of a fine shade or tint of grey, locally disseminated throughout the mass of the "ferrite" crystals. Numerous crystalline grains of "ferrite" remained of the normal silvery whiteness, but others showed by comparison a distinct grey tint, apparently indicating, as a result of the annealing, the existence of a comparatively attenuated carbide of iron of the nature of "sorbite" (owing to the diffusion of carbon into the ferrite crystals) in addition to the normal well-defined pearlite areas. The effect was observable in most of the annealed samples, although it appeared generally to be more marked in the annealed high-carbon and high-manganese steel rails. This grey colouration of some of the crystalline grains appeared to be due to a more attenuated dissemination or diffusion of the carbides throughout the mass of the metal, consequent on the annealing. These intermediate grey areas had generally a mottled aspect as seen in the micrographs. One of the Authors, in the year 1894, noticed this effect in the micro-structure of large forgings of wrought iron, containing only a small percentage of combined carbon, which had been subjected to prolonged heating, and Mr. Stead appears to have observed the same phenomenon in the year 1898.[1]

[1] Journal of the Iron and Steel Institute, 1898, pp. 145–189. Also "The Metallographist," October 1898.

The appearance is noticeable in Figs. 4 and 6, Plate 8; in these sections three distinctive features are visible, viz., the darker pearlite areas, the intermediate grey areas, and the silvery white pure ferrite areas.

The micro-sections conveyed the general impression that in the annealed samples the crystalline areas of the original carbides were larger and more widely dispersed than was seen to be the case in the normal unannealed rails, some portions of the intermediate spaces of ferrite having been apparently partially carbonized during the process of annealing, and the original carbide or pearlite areas had concentrated and amalgamated, having become larger in size although less in number.

General Conclusions.—After a careful consideration of the results of the various experiments, the following opinions may be tentatively expressed:—

(1.) There would appear to be considerable difficulties, both financial and practical, in annealing the whole of the large output of steel rails in the finished state, and in many instances the outlay and trouble might not perhaps adequately compensate for the possible advantages gained.

(2.) The various sets of experiments in this research have shown that, with medium-carbon and medium-manganese steel rails, the effect of annealing at any of the three temperatures employed (770° C., 850° C. and 940° C.), has been beneficial to the general physical properties of rails of this type, although it may be remarked that the maximum strength of those annealed at the highest temperature (940° C.) had rather fallen below the minimum desirable for rail service.

(3.) If, however, the practical difficulties of annealing large quantities of finished rails could be overcome, it would appear from the other portions of these experiments that the annealing, at any of the temperatures employed, had improved the physical properties of the high-carbon and high-manganese series of rails, by bringing their maximum strength more into consonance with the best requirements for durability and safe service, and at the same time by increasing their ductility. Such rails would therefore consequently be less liable to sudden fracture after annealing than before it. Annealing, if practical on the large scale, would therefore offer advantages in the case of rails of the high-carbon and high-manganese type, provided the annealing were not excessive. It may, however, be observed that similar satisfactory physical qualities may be secured without the expense of annealing, by keeping the chemical composition of the finished rail within the

limits of the analyses of medium-carbon and medium-manganese steel rails given in Appendixes I., II. and III., and by proper attention to temperature conditions during manipulation.

(4.) An important factor to be considered in the question of annealing steel rails is the loss in weight and size from the oxidation or scaling during the process, which the experiments of this investigation have shown to be considerable, Appendix IV. From this cause alone the cost of the permanent-way would be materially increased, in addition to the actual cost of the annealing. A practical objection to annealing the finished rail would be the difficulty of keeping the rail straight, and it is to be feared that many of them would be twisted and warped after the process. Further, there would be much expense in cleaning or scaling the whole surface of each rail after annealing. The rails would not be fit to be placed with safety in the permanent-way until this had been done in the case of each rail, as the thickness of the scale from effectual annealing is a considerable quantity to be reckoned with. The loss in mass strength from scaling is also indicated by the reduced dimensions of the rails after annealing, so that an enlarged section would be needed to allow for such loss of dimensions. Pending further light on the subject it does not at present appear to be clear that any great practical advantage would accrue from attempting the wholesale annealing of finished steel rails, although in some special cases there may perhaps be exceptions. Careful attention to the physical composition of the finished rails, and to their thermal treatment during manipulation, will go far to ensure a good rail, whether of acid-Bessemer or acid-Siemens steel, provided that the chemical composition is in reasonable practical accord with the type of medium-carbon and medium-manganese rails given in Appendixes I., II. and III., which appear to be best suited to ensure durability and safety.

(5.) The annealing at the lower temperatures of 770° C., and 850° C., affected the maximum strength and elongation, and also the elastic limit to some extent, both of the medium-carbon and medium-manganese steel rails, and of the high-carbon and high-manganese steel rails; but on annealing at the highest temperature, (940° C.), although the maximum strength and elongation were influenced, the elastic limit of both types of rails was comparatively little affected by the annealing at the latter temperature. The effect on the maximum strength and elongation of the high-carbon and high-manganese steel rails was marked, as is shown by the results given in Appendixes I., II. and III.

The foregoing remarks apply exclusively to the anneal

finished rails in bulk. If it is considered advantageous to anneal rails, this might probably be done with less difficulty and expense by annealing the ingots, under proper and effectual thermal conditions, or by allowing them to become quite cold before re-heating them for the final rolling. This method might probably somewhat more easily accomplish the object in view, viz., to ensure a more uniform micro-crystalline structure throughout the bulk of the rails, and also to promote greater uniformity in the general physical properties. Practical experiments on the large scale to determine this are being undertaken. It also remains to be decided, by further practical experiment, whether the increased expense and trouble involved in annealing rails would be compensated for by a corresponding advantage of increased durability and safety in actual practice on the permanent-way.

The Paper is accompanied by five drawings and four photographs, from which Plate 8 and the Figures in the text have been prepared.

[APPENDIXES.

APPENDIXES.

APPENDIX I.

Chemical Analyses of Unannealed Steel Rails containing Medium and High Percentages of Carbon and Manganese.

Six analyses made in each case.

Kind of Steel.	—	Combined Carbon.	Manganese.	Silicon.	Sulphur.	Phosphorus.
		Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Medium	Average of six analyses	0·395	0·750	0·058	0·066	0·066
High	Average of six analyses	0·473	1·097	0·069	0·054	0·059

Physical Properties of Steel Rails before and after Annealing.

Averages of six tests in each case.

Kind of Steel.	Part of Rail.	Annealed or Not Annealed.	Elastic Stress.	Ratio of Elastic to Maximum Stress.	Maximum Stress.	Elongation in 2 Inches.	Reduction of Area.
			Tons per Sq. In.	Per Cent.	Tons per Sq. In.	Per Cent.	Per Cent.
Medium	Rail Head	Not annealed	18·87	48·9	38·54	23·2	32·8
	,,	Annealed	18·93	51·1	36·97	25·7	41·8
	Rail Web	Not annealed	19·49	49·7	39·16	25·7	44·1
	,,	Annealed	19·43	53·5	36·34	26·6	44·5
High	Rail Head	Not annealed	25·59	54·2	47·33	15·3	20·8
	,,	Annealed	21·87	50·8	43·24	20·6	34·0
	Rail Web	Not annealed	26·07	52·3	49·84	16·3	27·6
	,,	Annealed	22·83	50·6	45·08	19·4	30·4

Annealing temperature, 770° C.

APPENDIX II.

Chemical Analyses of Unannealed Steel Rails containing Medium and High Percentages of Carbon and Manganese.

Six analyses made in each case.

Kind of Steel.	—	Combined Carbon.	Manganese.	Silicon.	Sulphur.	Phosphorus.
		Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Medium	Average of six analyses	0·390	0·775	0·059	0·067	0·063
High	Average of six analyses	0·478	1·003	0·090	0·065	0·063

Physical Properties of Steel Rails before and after Annealing.

Averages of six tests in each case.

Kind of Steel.	Part of Rail.	Annealed or Not Annealed.	Elastic Stress.	Ratio of Elastic to Maximum Stress.	Maximum Stress.	Elongation in 2 Inches.	Reduction of Area.
			Tons per Sq. In.	Per Cent.	Tons per Sq. In.	Per Cent.	Per Cent.
Medium	Rail Head	Not annealed	19·65	48·8	39·76	20·5	30·4
	„	Annealed	19·55	51·5	37·77	24·0	37·7
	Rail Web	Not annealed	20·19	50·4	39·97	23·9	40·7
	„	Annealed	18·71	50·4	37·11	25·0	41·2
High	Rail Head	Not annealed	28·12	56·0	47·00	15·4	19·9
	„	Annealed	23·32	52·2	43·53	19·6	28·6
	Rail Web	Not annealed	24·43	50·8	48·00	19·2	32·4
	„	Annealed	21·23	49·2	43·13	19·4	29·8

Annealing temperature, 850° C.

APPENDIX III.

Chemical Analyses of Unannealed Steel Rails containing Medium and High Percentages of Carbon and Manganese.

Six analyses made in each case.

Kind of Steel.	—	Combined Carbon.	Manganese.	Silicon.	Sulphur.	Phosphorus.
		Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Medium	Average of six analyses	0·411	0·697	0·065	0·076	0·063
High	Average of six analyses	0·464	0·981	0·078	0·068	0·066

Physical Properties of Steel Rails before and after Annealing.

Averages of six tests in each case.

Kind of Steel.	Part of Rail.	Annealed or Not Annealed.	Elastic Stress.	Ratio of Elastic to Maximum Stress.	Maximum Stress.	Elongation in 2 Inches.	Reduction of Area.
			Tons per Sq. In.	Per Cent.	Tons per Sq. In.	Per Cent.	Per Cent.
Medium	Rail Head	Not annealed	..	..	38·22	22·8	33·0
	"	Annealed	..	..	35·65	23·7	35·9
	Rail Web	Not annealed	19·33	49·7	38·87	25·1	40·2
	"	Annealed	17·53	49·5	35·39	24·7	39·1
High	Rail Head	Not annealed	22·88	51·4	44·27	14·6	18·2
	"	Annealed	20·38	50·4	40·29	21·9	33·6
	Rail Web	Not annealed	22·62	49·5	45·66	20·8	36·5
	"	Annealed	20·41	49·9	40·85	21·8	34·1

Annealing temperature, 940° C.

APPENDIX IV.

LOSS IN WEIGHT, DUE TO ANNEALING, OF STEEL RAILS CONTAINING MEDIUM AND HIGH PERCENTAGES OF CARBON AND MANGANESE.

Kind of Steel.	Temperature of Annealing.	Weight of Rail before Annealing.	Loss in Weight due to Annealing.	
			Per Cent.	Tons per Mile of Single Rail.
		Lbs. per Yard.		
Medium	910° C.	85[1]	3·20	2·145
		96	2·48	1·862
High	940° C.	85[2]	3·81	2·56
		92[2]	3·48	2·54

LOSS IN SIZE, DUE TO ANNEALING, OF STEEL RAILS CONTAINING MEDIUM AND HIGH PERCENTAGES OF CARBON AND MANGANESE.

Kind of Steel.	Temperature of Annealing.	Weight of Rail before Annealing.	Loss in various Dimensions due to Annealing.				
			Vertical Height.	Width of Rail Head.	Thickness of Rail Web.	Width of Rail Bottom.	Length in 30-Foot Rail.
		Lbs. per Yard.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Medium	850° C.	85[3]	0·77	1·50	4·37	1·04	..
		92	0 61	0·92	1·96	0·73	..
	940° C.	85[1]	1·018	..	..	..	0·0356
		96	1·05	..	..	..	0·0222
High	850° C.	85[1]	0·78	1 55	5·44	1·67	..
		92	0·35	1·28	3·47	1·47	..
	940° C.	85[2]	0·73	..	..	..	0·0371
		92[2]	0·757	..	..	..	0·0259

[1] Average of five rails. [2] Average of three rails.
[3] Average of four rails.

APPENDIX V.

CHEMICAL ANALYSES, BEFORE AND AFTER ANNEALING, OF STEEL RAILS, CONTAINING MEDIUM AND HIGH PERCENTAGES OF CARBON AND MANGANESE.

Kind of Steel.	Index Number of Rail.	Before, or After Annealing.	Chemical Analyses.						
			—	Combined Carbon.	Silicon.	Manganese.	Sulphur.	Phosphorus.	Iron, by Difference.
				Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Medium	1,437	Before	Rail Head	0·357	0·050	0·823	0·060	0·066	98·644
			Rail Foot	0·370	0·052	0·835	0·055	0·063	98·625
			Average	0·363	0·051	0·829	0·057	0·065	98·635
		After	Rail Head	0·380	0·063	0·893	0·061	0·069	98·534
			Rail Foot	0·390	0·065	0·905	0·061	0·071	98·508
			Average	0·385	0·064	0·899	0·061	0·070	98·521
High	1,667	Before	Rail Head	0·497	0·100	1·030	0·052	0·063	98·258
			Rail Foot	0·500	0·100	1·030	0·065	0·056	98·249
			Average	0·498	0·100	1·030	0·058	0·059	98·255
		After	Rail Head	0·520	0·104	1·116	0·053	0·068	98·139
			Rail Foot	0·520	0·104	1·116	0·060	0·071	98·129
			Average	0·520	0·104	1·116	0·056	0·069	98·135
”	1,458	Before	Rail Head	0·453	0·072	1·066	0·060	0·066	98·283
			Rail Foot	0·460	0·074	1·055	0·060	0·067	98·284
			Average	0·456	0·073	1·060	0·060	0·066	98·285
		After	Rail Head	0·470	0·087	1·012	0·065	0·069	98·297
			Rail Foot	0·480	0·093	1·001	0·062	0·067	98·297
			Average	0·475	0·090	1·006	0·064	0·068	98·297

APPENDIX VI.

EFFECT OF ANNEALING ON THE HARDNESS OF STEEL RAILS CONTAINING MEDIUM AND HIGH PERCENTAGES OF CARBON AND MANGANESE.

Kind of Steel.	Temperature of Annealing.	Serial Number.	Weight on Knife-Edge per Inch Width	Hardness before Annealing.		Hardness after Annealing.	
				Indentation of Test-piece.	Hardness Number.	Indentation of Test-piece.	Hardness Number.
			Tons.	Inch.		Inch.	
Medium	850° C.	1,817	6	0·027	216·6	0·029	206·9
			8	0·039	204·1	0·041	191·8
			10	0·052	190·1	0·056	177·0
			Average	..	203·6	..	191·9
„	„	1,847	6	0·024	244·9	0·025	235·3
			8	0·035	226·6	0·038	210·5
			10	0·047	212·8	0·050	198·0
			Average	..	228·1	..	214·6
„	„	1,437	6	0·022	263·1	0·025	240·0
			8	0·032	243·9	0·035	225·4
			10	0·044	227·2	0·048	207·4
			Average	..	244·7	..	224·3
„	940° C.	1,478	6	0·026	229·0	0·030	195·4
			8	0·037	215·0	0·043	183·9
			10	0·050	200·0	0·057	173·9
			Average	..	214·6	..	184·4
High	850° C.	1,458	6	0·019	315·8	0·022	263·1
			8	0·026	301·9	0·033	242·4
			10	0·036	276·2	0·044	227·2
			Average	..	297·9	..	244·2
„	„	1,667	6	0·019	307·7	0·020	295·5
			8	0·026	301·9	0·029	275·8
			10	0·034	294·2	0·038	259·7
			Average	..	301·2	..	277·0
„	„	1,318	6	0·018	320·9	0·021	281·7
			8	0·026	299·6	0·030	261·4
			10	0·035	284·1	0·041	242·1
			Average	..	301·5	..	261·7
„	940° C.	1,278	6	0·020	288·4	0·025	237·1
			8	0·029	275·8	0·035	226·6
			10	0·038	263·2	0·046	213·7
			Average	..	275·8	..	225·8

(*Paper No. 3435.*)

"The Design of a Main Outfall-Sewer."

By William Henry Haigh, Assoc. M. Inst. C.E.

In this Paper the Author discusses the design of a main outfall-sewer by reference to a scheme for adequately dealing with the discharge of the sewage of the western district of the borough of Cardiff.

The population of Cardiff at the present time is about 170,000, and the area of the borough is 8,408 acres, of which about 1,900 acres are foreshore. The sewerage of the borough is on the "combined" system, and the sewage is discharged through three main outfalls, each dealing with a district representing about one-third of the total area. The eastern and central districts discharge into the River Severn, whilst the western district has its outfall into the estuary of the River Taff, as shown in the sketch-map, Fig. 2, Plate 9. The main outfall-sewers of the eastern and central districts have been reconstructed and enlarged within recent years, but that of the western district has remained unaltered since its construction about 50 years ago.

The western district of Cardiff lies between the Rivers Taff and Ely (Fig. 2, Plate 9), and has an area of 2,000 acres, consisting of the following:—

	Acres.
Land at present built upon	950
Parks, commons and open spaces	140
Low-lying ground unsuitable for building purposes	460
Land available for building	450
Total	2,000

The existing outfall-sewer has an egg-shaped cross-section, 5 feet by 3 feet 9 inches, and was extended northwards in 1876, by a barrel-sewer 4 feet in diameter. Since that date numerous contributory sewers have been connected, which receive both the sewage and the surface-water of the whole of the district at present developed. It is due to the foresight of the engineers in constructing so large a

main sewer that the necessity for enlargement has not arisen long ago. The population of the district in 1881 was about 27,000. In 1891 it had increased to 39,800, and in 1901 to 57,500. It is now estimated at about 62,000. The district is thus rapidly and regularly increasing, and therefore, whilst the disposal of its sewage demands immediate attention, the scheme to be adopted should be thorough and well-planned, in view of further development of the district in the future by building. The present system of sewers is ample for adequately dealing with the dry-weather flow of the district and its probable increase for several years. The necessity for alteration arises solely from the incapacity of the sewers to take storm-waters. The outfall-basin is small and the outfall is tide-locked for about 5 hours during each tide, discharging on the ebb and at low-water. Consequently, during this period the whole of the sewage and surface-waters are impounded. When the doors are closed by spring-tides the sewage backs up to about 29 feet above low-water of mean spring-tides, or about 12 feet above ordnance datum; and, as the level of the lowest basement is only 15 feet 2 inches above ordnance datum, on a storm arising the storage-capacity is immediately exhausted and at once produces flooding. The district is exceptionally difficult to drain by reason of its low-lying situation. A large part of the area is practically level and at about the same height as high-water of ordinary spring-tides. Equinoctial tides, assisted by strong winds, have overflowed the embankments, and as the sewer-outfall at this time is tide-locked there is no escape for the overflowing water, and considerable damage has resulted. Further, the storage-capacity of the existing sewers below the level of the lowest drained basement is only about 2½ million gallons. These facts constitute the salient points to be held in view in considering a scheme designed to carry off all storm-waters, and so obviate flooding, despite the low levels of the district. The scheme to be adopted should admit of a free discharge at all times from all subsidiary and intercepting sewers. It is obvious that, in order to secure this, either the outfall should be free, *i.e.*, never tide-locked, or there should be a storage-capacity below the level of the lowest basement sufficient to hold the impounded sewage and storm-water during the period of tide-lock. The Bristol Channel is subject to abnormally high tides. At Cardiff extraordinary tides rise as much as 27 feet above ordnance datum, and fall 19 feet below it, Fig. 1, Plate 9.

Since the Author's object in this Paper is not to discuss the relative merits of the various systems of sewage-disposal, but,

having decided on a scheme, to present a few notes on its design, it is premised that, for the particular instance under consideration, disposal of the sewage by means of a direct outfall to the sea is the most suitable scheme and the one to be adopted. It is further premised that the outfall is to be taken far out to the open sea, where it will be inoffensive, and also, on account of the length of the trunk-sewer, plenty of room for storage will be provided. The first step necessary is to determine the precise location of the outfall. On reference to the map (Fig. 2, Plate 9) two points suggest themselves as suitable, and likely to fulfil the requirements already indicated. These positions are at or about the points marked Lavernock Point and Sully Island; but a careful survey of the coast and observation of the tide-currents must be made before the most suitable position can be decided upon. Both positions fulfil the condition of isolation, being well away from neighbouring towns and well out to the sea, where spring-tides have a velocity of 4½ knots per hour on the flow and 5 knots per hour on the ebb. Under the supervision of the Author, a series of experiments was carried out in order to gauge the tide-currents from each suggested point of outfall. These extended over 14 days, including every height and strength of tide from one highest spring-tide to the next highest spring-tide, completing a cycle of tides. A gauging was taken, starting from the proposed point of discharge, at every hour in each day's tide, *i.e.*, 12 hours daily from high-water of one tide to high-water of the next tide. When darkness prevented a gauging at any hour, the experiment was carried out at the same hour in the next (*i.e.*, a fortnight later), or at any convenient subsequent corresponding tide. The exact position of low-water mark at each point was first fixed by observation of prominent landmarks, so that a boat could be brought over the precise spot at any state of the tide. The float used was a wooden scantling about 2 feet 6 inches in length and 4 inches square in cross-section. Pieces of lead were tacked on one end so that when floating the other end projected about 6 inches above the water. At high-water of the highest spring-tide the first float was dropped in from a boat at the starting-point, the boat following it as it drifted with the tide. Observations of its position, with reference to prominent landmarks, were taken from time to time. For this purpose a prismatic compass was used, and while proving fairly accurate for near sights it was doubtful for long sights. Not less than three readings to different objects were taken at each observation. Another float was started one hour after high-

water, and so on for every hour to one hour before the next high-water. The observations were then plotted on charts and a tabulated statement of the conditions of wind, weather and sea at each experiment was prepared. The "set" of the currents from Sully Island is very unsatisfactory for the purposes of an outfall. The floats were found to "hug" the coast too closely, and on neap-tides to hang about in the bight west of the island. The result of the experiments from Lavernock Point, however, was eminently satisfactory, and diagrams showing the "set" of the tidal currents are given in Figs. 3, Plate 9. The lines indicate the courses of the floats during each of the fourteen tides.

Having thus ascertained that Lavernock Point is in all respects very suitable as the point of discharge for the intended outfall-sewer, the next step is to decide the period of discharge. The diagrams indicate that the best time will be between 1 hour to 1½ hour before high-water and 2½ hours to 3 hours after high-water on each tide, a period of 4 hours out of every 12 hours. The courses of the floats during these particular hours are shown by the diagrams to be well away from the shore, and at this time a very strong tidal current is running off the Point, so that the sewage discharged will be at once drawn into the swiftly-flowing current, and before the return-tide will have been carried far out to sea, and so disintegrated and mixed that no trace of sewage will be left.

It has previously been stated that the level of the lowest point in the western district to be drained is only 15 feet 2 inches above ordnance datum, while the level of high-water of mean spring-tides is 20 feet 8 inches above ordnance datum, and as discharge is to take place at high-water it is obvious that pumping must be resorted to in order to lift the sewage to such a height that it may discharge against the highest tides. The points of commencement and termination of the main outfall-sewer having been fixed, the course it shall take between these points has next to be decided. The route to be adopted is governed by the following considerations, viz.:— (1) The storm-waters may be disposed of (after a certain amount of dilution of the crude sewage) by overflow near the commencement of the trunk-sewer, into the River Ely, which empties into the tidal estuary of the River Taff. The pumps for lifting the normal and diluted sewage will then be placed somewhere between this storm-water overflow and the outfall. It will be necessary to pump the sewage through the rising-mains to a height sufficient to allow the sewage to discharge at the outfall by gravitation at high-water. Therefore the route of the trunk

sewer should be such that it will pass through ground high enough to allow of this taking place. (2) The route should be so planned, if possible, that it will be capable of receiving with advantage the sewage of neighbouring towns and villages, on the way to the outfall, not satisfactorily dealt with at present. (3) With the view of minimizing the cost, the sewer should follow as closely as possible the contour of the land, so that unnecessarily deep cutting or high embankments may be avoided, at the same time, however, not deviating too widely from a straight course, otherwise the increased length of sewer may involve greater expense than deep cutting or tunnelling, and may also necessitate a greater fall.

A map covering the probable area should be prepared, showing levels and contour-lines. In the present instance a particularly favourable site in regard to the first of the foregoing considerations presents itself, for at the point marked "E" on the sketch map (Fig. 2, Plate 9), it will be seen that the storm-water may be conveniently discharged, whilst near at hand the ground suddenly rises to a height of about 160 feet above ordnance datum, whence, after pumping, the sewage will have ample fall to gravitate to the outfall. This spot is therefore marked as the best site for the pumping-station and storm-water overflow.

With regard to the second consideration, it will readily be seen that the course should lie between Penarth and Dinas Powis, so that the sewage of these two districts may be received, if necessary, together with that of any outlying villages on the route.

The requirements of the third consideration are most nearly complied with by following the course indicated on the plan (Fig. 2, Plate 9), as will be seen by reference to the longitudinal section, Fig. 4, Plate 9.

Having decided on the precise route to be followed, the length of the trunk-sewer is fixed, and the next step is to calculate the size and inclination of the sewer that will best fulfil the requirements demanded. The following is an outline of the details which determine these points in the scheme thus briefly described.

The sewer is designed so that, while fully adequate for the present needs, it will be capable of meeting the requirements of the future. The population of the western district is steadily increasing. It has been stated that in 1891 the population was 39,797 and in 1901 it was 57,433. Taking the rate during this period as a basis, the estimated population in future years is arrived at in the following manner:—

Population in 1891 = 39,797; Log. 39,797 = 4·5998503
" " 1901 = 57,433; Log. 57,433 = 4·7591615

Difference . . . 0·1593112

Allowing 30 years as a reasonable future period to be provided for, then

0·1593112 × 3 = 0·4779336
Add . . . 4·7591615

5·2370951

which is the logarithm of 172,622, the estimated population, which will have overflowed the existing Borough boundary, in 1931, or say, 180,000 as the ultimate population of the extended western district to be provided for in the scheme; and as the rate of increase is becoming smaller, the figure assumed, viz., 180,000, is not likely to be attained until considerably later than the year 1931, and therefore the Author thinks it will be admitted to be a sufficiently liberal allowance. The population, of course, governs only the dry-weather flow. The amount per head per day was calculated by careful gaugings at the existing outfall-sewer. Series of light floats were sent down at intervals through a long length of straight sewer between two manholes near the outfall. The length of time taken by each float between the manholes and the hydraulic mean depth were booked, and the results are given in the following Table. The experiments were carried out only in dry weather and during the six busiest hours, viz., 9 A.M. to 3 P.M.

Time of Day.	Discharge in Cubic Feet per Minute.	Velocity in Feet per Minute.	Discharge in Cubic Feet per Minute.	Velocity in Feet per Minute.
9 a.m.	289·20	101·47	249·74	97·17
10 a.m.	238·03	91·20	219·40	89·92
11 a.m.	218·00	91·98	230·44	91·80
12 noon	247·96	92·87	241·54	90·43
1 p.m.	228·77	92·24	223·57	90·52
2 p.m.	214·52	90·52	217·59	80·09
3 p.m.	216·40	89·42	219·85	89·01

This shows an average discharge of 232·5 cubic feet per minute, which, taking the population as 57,433, is equal to a little more than 18 gallons per head per day, half discharged in 6 hours. For the purposes of the calculations in the scheme, this figure was increased to 20 gallons per head per day.

The ultimate dry-weather flow is therefore

180,000 × 20	3,600,000 gallons per day		
Half discharged in 6 hours . .	1,800,000	„	
Rate	5,000	„	„ minute

or 801·28 cubic feet per minute.

But, as has already been pointed out, the dry-weather flow, which is regular and can be definitely determined, is a small item; the great main feature is the storm-water, which is an uncertain factor. To arrive at an estimate of its amount, it is necessary to determine (1) the area to be drained; (2) the amount of rainfall; and (3) the rate at which it will reach the sewer. The area of the western district at present built upon is 950 acres, with a population of about 58,000. Assuming that the same density is maintained as the population increases and the area of the district is extended, the area covered by an ultimate population of 180,000 will be 2,948 acres, which includes roads and streets, buildings, back-yards and gardens. At a reasonable estimate, rain-water falling on about two-thirds of this area (*i.e.*, on 1,965 acres) will find its way to the sewer. Adding, say, 35 acres for roads in parks and open spaces, the result is a total of 2,000 acres. The sewer must therefore be so designed that, in addition to the dry-weather flow, it will be capable of dealing with the rainfall on 2,000 acres. It is, of course, obvious that the heaviest rainfall must be taken into account. A tabulated list of rainfalls[1] on every day during the years 1891–1900 inclusive accompanies this Paper. The heaviest recorded rainfall in one day was 1·83 inch. In the following calculations the maximum rainfall allowed for is ½ inch in one hour; and, although this may very occasionally be exceeded, it is fair to assume that, as there are many miles of tributary sewers in the district, none of which is smaller than 3 feet 3 inches by 2 feet in cross-section, these will be sufficient to store such excess during the very short time that an extreme rainfall is likely to last. To arrive at the rate at which the rainfall will reach the sewer, the Author has adopted the Burkli-Zeigler formula:—

$$\left\{\begin{matrix}\text{Cubic feet per}\\ \text{second per acre}\\ \text{reaching sewer}\end{matrix}\right\} = \left\{\begin{matrix}\text{A coefficient}\\ \text{according to}\\ \text{judgment}\end{matrix}\right\} \times \left\{\begin{matrix}\text{Average cubic}\\ \text{feet of rainfall}\\ \text{per second per}\\ \text{acre during}\\ \text{heaviest fall}\end{matrix}\right\} \times \sqrt[4]{\left\{\dfrac{\begin{matrix}\text{Average slope of}\\ \text{ground in feet}\\ \text{per 1,000 feet}\end{matrix}}{\begin{matrix}\text{Number of acres}\\ \text{drained}\end{matrix}}\right\}}$$

The coefficient for paved streets is 0·75, for ordinary cases 0·625, and for suburbs with gardens, lawns and macadamized

[1] This list may be consulted in the Library of the Institution.

streets, 0·31. As the district under consideration contains a fair proportion of suburbs, and as most of the streets are macadamized, the Author is of opinion that a coefficient of 0·5 may reasonably be assumed. With regard to the third term in the formula, it is found that each inch of rainfall per hour corresponds very closely with 1 cubic foot per second per acre, and calculation is thus simplified. For the last term, the general slope of the ground in the district is 3 feet per 1,000 feet.

The formula thus becomes, for the particular case,

Quantity per second per acre reaching sewer—

$$= 0 \cdot 5 \times 0 \cdot 5 \times \sqrt[4]{\frac{3}{2,000}}$$

$$= 0 \cdot 04925, \text{ or, say, } 0 \cdot 05 \text{ cubic foot.}$$

Hence the total rainfall reaching the sewer from the district to be drained is 6,000 cubic feet per minute. To this must be added the dry-weather flow of 801 cubic feet per minute, giving a total of, say, 6,800 cubic feet per minute as the maximum flow to be provided for. It will be seen that about six-sevenths of this amount is purely storm-water.

It is therefore obviously undesirable to make provision for carrying all this flow of water several miles to the outfall if a satisfactory method of disposal of the storm-water can be arranged near the commencement of the trunk-sewer, and, as already stated, this opportunity is offered by discharge into the tidal estuary of the River Ely. It is recognized that sewage diluted with five times its volume of rain-water is a practically harmless effluent, especially when discharged into a tidal river in flood, and therefore no evil can result from the discharge of storm-water, over and above this dilution, into a tidal estuary. Taking the dry-weather flow as 20 gallons per head per day, this, with five times dilution, will give 120 gallons per head per day; but by mutual agreement with interested authorities it was decided to increase this amount to 150 gallons per head per day, and all storm-water, after diluted sewage at the rate of 150 gallons per head per day has been carried off, will be discharged into the River Ely.

The sewer from this point to the outfall remains to be designed of such capacity that it will efficiently carry off sewage at the rate of 150 gallons per head per day for an ultimate population of 180,000 in the western district; and it is desirable that it should also be capable of serving the districts along its route. The country through which the sewer passes is rural, and allowance is made for a population of 20,000 to be treated on the

same basis. Hence the sewer will be required to deal with a total population of 200,000 at the rate of 150 gallons per head per day, which represents a flow of 3,338 cubic feet per minute. This, therefore, will be the maximum rate of flow of sewage towards the outfall. It has already been stipulated that the time for discharge should be limited to a period of 4 hours on every tide. Therefore, during 8 hours prior to discharge the sewage must in some way be stored up. Two methods for storage present themselves: first, the construction of a large reservoir near the outfall; and second, by constructing the last portion of the sewer of such a size that it will act as a storage-tank or reservoir. The latter method recommends itself, and the tank-sewer is easily capable of extension if greater storage-capacity be required at any future time. When the population has reached the limit of 200,000, the storage required, theoretically, for 8 hours' flow at the rate of 150 gallons per head per day will be 10 million gallons, *i.e.*, on the assumption that the 4 feet 9 inches trunk-sewer may be running *full* for a period of eight consecutive hours. But this is most unlikely, even on a persistently wet day, and therefore it would be an unnecessary and wasteful expense to construct a storage-sewer of such excessive capacity. The Author considers that if provision be made for half this amount it will be sufficient, leaving any extension that the requirements of the future may demand to be carried out later. This means providing storage to the amount of 5 million gallons, which must be discharged in 4 hours. The Act of Parliament under which the scheme was sanctioned stipulates for a minimum storage-capacity of 4½ million gallons. In the rare event of this storage being exhausted before the time for discharge arrived, the overflow would empty into the sea at Lavernock Point, and as the storage provides for dilution to 7½ times the maximum dry-weather flow such occasional overflow into the open sea can do no possible harm at any state of the tide.

The leading features of the scheme having been settled and the capacities required having been arrived at, the determination of the size, section, levels and inclination of the sewers that shall satisfy the requirements thus far set forth may be proceeded with. The main feature is the discharging-capacity of the trunk-sewer. Many formulas have been evolved for such calculations, and as they vary considerably it is important that the most reliable formula should be adopted. A brief consideration of the principal formulas may therefore not be out of place. Most of the formulas for calculating the flow of water in pipes and culverts are based

upon that evolved about 100 years ago by de Chezy, viz., $v = C\sqrt{RS}$, where v denotes the velocity in feet per second, R the hydraulic mean depth, S the sine of the angle of inclination, and C a constant to be determined by experiment. Eytelwein fixed the value of C at 94, on which basis the formula was modified by Beardmore to $V = 55\sqrt{R \times 2F}$, where V is the velocity in feet per minute and F the fall in feet per mile. This formula is best known, and as a practical working formula is still most in use; but it is apparent that it suffers from the disadvantage that the value of C is always the same and makes no allowance for variation in size and construction of the culvert; it is therefore desirable to obtain a formula that shall take this into consideration. With this object formulas were propounded by Weisbach, and Darcy and Bazin, but these are unwieldy, and involve much calculation. One of the most recent formulas, and one that calls for attention, being the result of much study and careful experiment, is that of Ganguillet and Kutter. This formula is similar to the original expression by de Chezy, but the value of C is minutely calculated for all conditions, the formula taking the form :—

$$V = \left\{ \frac{41 \cdot 66 + \frac{1 \cdot 811}{N} + \frac{0 \cdot 00281}{S}}{1 + \left(41 \cdot 66 + \frac{0 \cdot 00281}{S}\right)\frac{N}{\sqrt{R}}} \right\} \sqrt{RS}$$

It will be seen that another variable coefficient is here introduced, viz., N, which is the coefficient for friction against the surface, and varies between 0·010 for smooth channels and 0·030 for rough channels, being taken as 0·013 for ashlar or neatly-pointed brickwork. It will be conceded that, by reason of the carefully worked-out value of C, this formula should be correct, and it may be accepted as the most reliable under all conditions, but it is formidable in the array of figures necessary and a stumbling-block to expedition in practical calculations. A formula which, while retaining the same reliability and adaptability for all conditions, is more readily applied, is that evolved by the late Mr. W. Santo Crimp and Mr. C. E. Bruges, viz. :—

$$V = 124\sqrt[3]{R^2}\sqrt{S}$$

This formula is the outcome of close investigation and comarison of the best-known formulas hitherto, including the -tter formula, and of many careful experiments and critical ervations of the flow of water through iron mains and sewers

varying between 9-inch stoneware-pipes and 9-foot brick-culverts. Adopting a coefficient of roughness, N, between 0·012 and 0·013, in the Kutter formula, and plotting the results obtained from the two formulas in the form of diagrams for different inclinations, it will be discovered that the lines drawn through the points representing the discharges from culverts of various diameters practically coincide. Similar plottings will also show that, in general, smaller discharges are given by the use of the Darcy, Weisbach, and Beardmore formulas, and in the order named, the divergence increasing with the size of the culvert and as the gradient becomes flatter. All formulas are, of course, subject to allowance for roughness of the surface of the channel, and Messrs. Crimp and Bruges give it as the result of their investigation that the discharge may differ from that given by the formula by as much as 10 per cent. more for very smooth channels, and the same percentage less for very rough channels. Allowance must therefore be made, at the discretion of the engineer, according to the class of work. The Author has no hesitation in recommending the adoption of the formula—

$$V = 124 \sqrt[3]{R^2} \sqrt{S}$$

for general use, and it has been adopted for the calculations in the scheme which forms the subject of these notes, in which the sewers will be constructed of superior brickwork neatly pointed.

Having decided upon a satisfactory formula for the basis of the calculations, the sizes and inclinations of the sewers that will best fulfil the requirements may now be investigated. On reference to the sketch-map (Fig. 2, Plate 9) the advisability will be at once appreciated of "tapping" the present main sewer at two or three points by means of intercepting-sewers converging at a convenient point, forming the commencement of the new trunk-sewer. The points marked A, B and C on the map appear to be the most suitable at which to connect to the existing system, whence the intercepting-sewers form a junction at D, which is to be regarded as the head of the trunk-sewer. A point that has not yet been discussed, but upon which there can be little question, is the shape of the sewer to be adopted. There are three shapes of cross-section that may be considered, viz., circular, ovoid, and egg-shaped. The ovoid is a compromise between the circular and the egg-shaped. The chief points to be borne in mind are that the sewer should be self-cleansing and capable of taking the maximum discharge. For comparatively small sewers the egg-shape possesses distinct advantages, for the following reasons:—(1) the shape of the

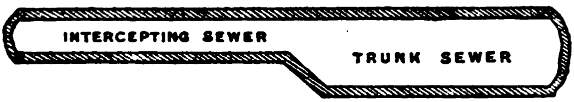
invert gives a greater depth and consequently increased efficiency during the dry-weather flow of sewage; (2) as the water rises, due to rain, the capacity of the sewer increases rapidly; (3) for the same cross-sectional area it gives greater head-room, and is therefore more convenient for sewermen to travel through; and (4) less width of trench is necessary. In large sewers exceeding, say, 4 feet in diameter, a circular section is to be preferred, since (1) it is simpler of construction, being of one radius, which obviates the use of different centering—a fact which, in the Author's opinion, is more appreciable as the sewer becomes larger; (2) the circle is best adapted for tunnel work; (3) size for size, the circular sewer has the greater carrying-capacity; an egg-shaped sewer, 9 feet by 6 feet, is equalled in capacity by a circular sewer 7 feet 3 inches in diameter. As a comparison it may be stated that sewers of equal carrying-capacity when full have the following dimensions, D, the diameter, being unity.

	Width at Springing.	Height.
Circular.	1·20	1·20
Egg-shaped.	1·00	1·50
Ovoid	1·07	1·38

In the scheme here outlined a circular section has been adopted, except in the case of the intercepting-sewer No. 3, which has least work to do, and is egg-shaped, 3 feet 9 inches by 2 feet 6 inches, the existing main-sewer being 5 feet by 3 feet 9 inches at the outfall. The old main-sewer above the outfall is 4 feet in diameter, and will be intercepted at the points A and B by two sewers of the same diameter. It has been stated that the sewers should have such falls as will make them self-cleansing, but at the same time the inclination must not be so excessive as to cause damage to the invert and walls of the sewer by undue attrition. It is found that a bottom velocity of 1 foot per second will move fine gravel, and a velocity of 2 feet per second will move pebbles 1 inch in diameter. The velocity, of course, varies at different depths, the least, mean, and maximum being in the proportion of 3, 4 and 5, and in very slow currents 2, 3 and 4. Hence the mean velocity should not fall below $1\frac{1}{2}$ foot to $2\frac{1}{2}$ feet per second. As a matter of observation, however, it is found that the mean velocity in sewers should not be less than 2 feet per second. With regard to the maximum velocity permissible, some authorities have placed the limit at $4\frac{1}{2}$ feet per second, but the Author is of opinion that when a sewer is well constructed of vitrified bricks with cement joints 6 feet per second may be taken as a safe limit. In the scheme under investigation a velocity of 3 feet to 4 feet per

second has been aimed at, thus giving a fairly quick discharge and avoiding liability to silting. The level of the invert at D, the point of commencement of the trunk-sewer, is necessarily governed by the level of the lowest point to be drained. The levels of the invert at the fixed points A, B and C, where the three intercepting-sewers commence, are respectively 12·27, 8·40, and 6·50 feet above ordnance datum. The last-mentioned level, being the lowest, governs the level at D. Taking ordnance datum as the lowest level at which it would be advisable to discharge at the storm-water overflow, it will be seen that between the level at C and the point of overflow, a distance of about 1 mile 972 yards, there is a fall of 6·5 feet in which to contrive working-gradients for the sewers. If the inverts of the intercepting-sewer and trunk-sewer were in one true "boning" this would be more than sufficient, assuming an average working-gradient of 3 feet per mile, but as it is obvious that the trunk-sewer, into which three intercepting-sewers (two 4 feet in diameter, and one 3 feet 9 inches by 2 feet 6 inches) empty, must be considerably larger than

Fig. 5.



either, it will be apparent that at D, the converging-point, a drop equal to the increase in diameter of the sewer should occur (*Fig. 5*). From C, allowing the minimum velocity of 2½ feet per second, this will give for a sewer 3 feet 9 inches by 2 feet 6 inches a gradient of 1 in 1,500, which brings the level of the invert at D to 4·30 feet above ordnance datum. The other two intercepting-sewers, from A and B, may be laid at steeper gradients, there being plenty of fall. From A (12·27 feet above ordnance datum) there will be a 4-foot barrel-sewer. Allowing a velocity of 4 feet per second in this sewer a gradient of 1 in 1,000 will be required, which gives a level at D 6·50 feet above ordnance datum, from which it would fall rapidly round the curve to its junction with the trunk-sewer. The sewer from B (8·40 above ordnance datum) will also be 4 feet in diameter, and the distance to its junction at D being short, with a comparatively big drop, a velocity of 5 feet per second may be allowed, resulting in a gradient of 1 in 600 and making the level of the invert at D 6·93 feet above ordnance datum, from which there is a quick fall to the trunk-sewer. Thus all the tributary

sewers have been collected to the one point, D, and it now becomes necessary to determine the size of the trunk-sewer and the level of the invert at the commencement. It has already been assumed that the level at the overflow shall be that of ordnance datum.

The combined emptying-capacity of the three intercepting-sewers into the trunk-sewer is:—

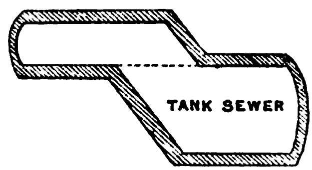
	Cubic Feet per Minute.
For the 4-foot circular sewer at a gradient of 1 in 1,000 .	3,817
" " " " " 1 in 600 .	2,956
For the 3 feet 9 inches by 2 feet 6 inches circular sewer at a gradient of 1 in 1,500	1,112
Total	7,885

It has been calculated that the maximum capacity to be provided should be 6,800 cubic feet per minute; it therefore appears that slightly smaller intercepting-sewers would answer the purpose, but, as previously noted, the sizes given are best suited to the existing system. It would, however, be uncalled for to design the trunk-sewer for a greater discharge than 6,800 cubic feet per minute, and this figure will be aimed at, the extra capacity of the intercepting-sewers forming a little extra storage in the event of excessive rainfall for a short time. The combined cross-sectional area of the three intercepting-sewers is 32·3 square feet. Assuming as a preliminary a gradient for the trunk-sewer equal to the average inclination of the intercepting-sewers, this would require a rather less cross-sectional area, as the required capacity is about 1,000 cubic feet per minute less than that of the combined intercepting-sewers. The diameter of a circle whose area is 32·3 square feet is about 6·4 feet. For a trial, therefore, a circular trunk-sewer 6 feet in diameter may be assumed. To discharge at the rate of 6,800 cubic feet per minute it is found that a fall of 1 in 1,650 is necessary, which gives a velocity of 4 feet per second. This would be a very satisfactory sewer, and if the levels will admit it may be adopted. Taking ordnance datum as the level of the invert at the overflow, it is found that this gradient results in the level of the invert at D being 3 feet above ordnance datum, which is 1·30 foot below the level of the invert of the lowest intercepting-sewer at the same point. The crown of a trunk-sewer 6 feet in diameter would thus be 2·50 feet above the level of the invert of the intercepting-sewer at C, and 0·60 foot above that at B; but as the crown of the sewer at C is 1·25 foot above the crown of the trunk-sewer at its highest point it will be seen that if the sewer be

constructed as proposed it will satisfactorily fulfil the requirements demanded. The first part of the scheme has therefore been determined, viz., a trunk-sewer, from the point of juncture of the intercepting-sewers to the storm-water overflow, which shall be a conduit 6 feet in diameter laid at a gradient of 1 in 1,650 throughout, the level of the invert at the commencement being 3 feet above ordnance datum, the level at its termination, Fig. 4, Plate 9.

In an earlier part of this Paper it has been shown that after disposing of the storm-waters the sewage would require to be "lifted" a certain height, in order that it might gravitate to the outfall. The height to which the sewage must be raised depends on (1) the level of the invert of the sewer at the outfall, (2) the length of the route, (3) the rate of inclination, and (4) the general level of the ground-surface along the route; and these four factors must be considered collectively. It has been decided that the discharge shall take place at high-water. The height of high water of ordinary spring-tides is 20 feet 8 inches, and of extra ordinary tides 27 feet above ordnance datum. The height of 25 feet above ordnance datum may therefore be taken as a reasonable level for the invert at the termination of the sewer, with the practicability of lowering it to not less than 20 feet above ordnance datum if desirable. With a view to economy of construction the trunk-sewer should be designed so that, having regard to gradient, it may be kept within a reasonable distance of the surface, and so obviate unnecessarily deep cutting, or, on the other hand, "cropping out" above the surface at low places, which would involve piling and covering. Since the construction of the last portion of the trunk-sewer as a storage-reservoir governs that of the whole sewer, this portion will be considered first. The required storage is calculated to be about 5 million gallons. This capacity will be obtained by largely increasing the size of the sewer for a certain length, and dropping the invert. When the tank-sewer is full, the sewage will have "backed" up some distance along the trunk-sewer, and in order to fill the reservoir before encroaching on the trunk-sewer it will be seen that the tank should be dropped so that its crown will be level with the invert of the sewer, *Fig. 6*; but if this is not feasible, on account of the levels, the "backing-up" will be minimized by

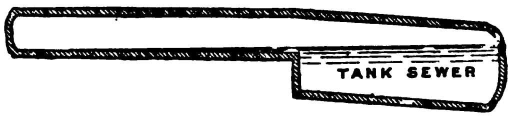
Fig. 6.



giving the storage-sewer a steeper gradient than the trunk-sewer which empties into it, *Fig. 7.*

Assuming, for a preliminary trial, a length of 1 mile and a diameter of 12 feet for the tank-sewer, the result is a capacity of 3,372,300 gallons, which is hardly sufficient. Increasing the length to $1\frac{1}{12}$ mile and the diameter to 13 feet, storage-capacity for 4,740,000 gallons is obtained, and as, when the tank-sewer is full, the sewage will have backed-up some distance in the trunk-sewer, storage for about 5,000,000 gallons will be obtained. Having thus decided on the length and diameter of the storage-sewer, the invert-level must be fixed. Allowing a minimum of 3 feet of cover at the shallowest part of the route, and working from 25 feet above ordnance datum at its termination, the result is a gradient of 1 in 1,400 and an invert-level of 29·08 feet above ordnance datum at the commencement of the 13-foot sewer. This is satisfactory, and may be adopted, provided these levels will fall in with the requirements of the trunk-sewer; otherwise there is the option of lowering the storage-sewer not more than 5 feet; for, although at

Fig. 7.



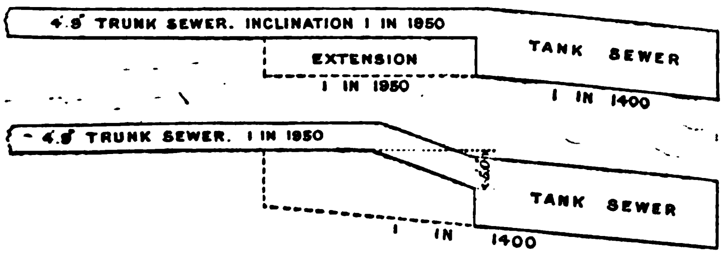
extraordinary tides high-water would be above the level of the invert at the outfall, it must be remembered that the head of sewage behind will discharge against the tide, which also will be receding during the 4 hours that the storage is emptying. The plan of dropping the reservoir-sewer 5 feet will probably be to the advantage of certain low-lying land in the vicinity, in the event of such land requiring to be drained at some future time. The lowering of the reservoir-sewer would also allow extension to be made at the same gradient, viz., 1 in 1,400, instead of following the inclination of the 4 feet 9 inches sewer, a portion of which it would displace, and the gradient of which is 1 in 1,950. This will be, perhaps, more readily understood by reference to *Figs. 8.*

It is required now to design a trunk-sewer that shall have a carrying-capacity of 3,338 cubic feet per minute. A trial on the plotted sections of the proposed route proves that it is possible, without surface-work except where crossing streams, to secure a fall of about 1 in 2,000, without lowering the tank-sewer below the levels suggested. A gradient of 1 in 2,000 is perhaps a little

flat, but will be satisfactory provided a velocity of 3 feet per second is obtained. A culvert, 4 feet 9 inches in diameter, at a gradient of 1 in 1950, will give a discharge of 3,348 cubic feet per minute at a velocity of 3·15 feet per second. This may therefore be adopted, with confidence in its effective results. Keeping the crown of the sewer level with the crown of the tank-sewer at their junction, the reduced level of the invert at that point becomes 37·33 feet above ordnance datum, and at the commencement of the sewer 46·35 feet above ordnance datum.

Next to be considered is the outfall-culvert on the foreshore, to low-water level. The sewage for 8 hours is locked in the storage-sewer. About 1 hour or 1½ hour before high-water, a valve would be opened at the termination of the storage-sewer and the contents would be discharged in 4 hours. The capacity of the reservoir-sewer will be about 5 million gallons, to which must be added the

Figs. 8.



discharge from the 4 feet 9 inches trunk-sewer during the 4 hours the valve is open, which for this purpose may be taken as its full discharging-capacity; this is equal to 5 million gallons in 4 hours. Hence the total discharge during 4 hours to be provided for will be 10 million gallons. The point of outfall is at low-water level, while discharge commences at about high-water, so that the outfall is of the nature of a submerged orifice, and the rate of discharge is due to the "head" of water in the sewer. When the reservoir-sewer is full, the surface-level of the contents will be about 42 feet above ordnance datum, and the least head will be against spring-tides, which rise about 21 feet above ordnance datum. This would give a head at the commencement of discharge of about 21 feet. At the end of 4 hours the reservoir would be practically empty at 25 feet above ordnance datum, and the tide would have dropped to about 2 feet above ordnance datum, giving a head of 23 feet, or, say, a mean head, during the discharge, of 22 feet. Neap-tides rise to

only 12 feet above ordnance datum, thus giving a mean of $4\frac{1}{2}$ feet more head of water in the sewer than at spring-tides, but it is the minimum head that must be taken into account. The valve need not be opened to the same extent on neap-tides, and in order to maintain a regular discharge during 4 hours on every tide the valve will require to be regulated according to the height of each tide. It will be well to provide valves in duplicate in case either valve should fail to act at any time. To arrive at the size of valve necessary, the outlet may therefore be regarded as a submerged orifice, from which discharge takes place under a mean head of 22 feet, and may be calculated from the Eytelwein formula $D = 0 \cdot 531 \sqrt[5]{\frac{LW^2}{H}}$, where D is the diameter of the orifice in inches, L the length of the outfall-culvert in feet, W the quantity discharged in cubic feet per minute, and H the head in feet. The maximum quantity to be discharged, viz., 10 million gallons in 4 hours, is equal to 6,677 cubic feet per minute. The formula, therefore, gives $D = 0 \cdot 531 \sqrt[5]{\frac{1,600 \times 6,677^2}{22}} = 42 \cdot 4$ inches. This, however, is the maximum diameter of outfall-culvert required in the event of such a combination of circumstances arising as the storage-sewer being full, with the trunk-sewer emptying at its full capacity during four consecutive hours, and at the same time the whole discharging against the highest tide. Such a condition is unlikely to occur, or at any rate very rarely. And, taking this into consideration, the Author is of opinion that an outfall-culvert 36 inches in diameter will be found perfectly satisfactory. In the event of this failing at any time to empty the tank in the stipulated period, the residue would be left for discharge at the next tide, and it is highly improbable that such a contingency would arise at two consecutive tides. The outfall-culvert will consist of cast-iron pipes laid along the foreshore from the termination of the reservoir-sewer to the point of outfall at low-water. In order to provide against any remote contingency, and to prevent backing-up in the 4 feet 9 inches trunk-sewer, a means of overflow should be arranged at the termination of the storage-sewer, so that if the storage-capacity should be exhausted before discharge takes place the extra volume will be released. This is provided by constructing a weir at the level of the highest point in the soffit of the tank-sewer with an overflow to the outfall-culvert. Should the tank-sewer be ultimately extended by enlarging the latter part of the 4 feet 9 inches trunk-sewer, the overflow-weir would, of course, be correspondingly raised. In close proximity to the

outfall there must be a cottage for a man, whose duty it will be to work to a tide-table and open and shut down the penstock-valve at the commencement and termination of the period for discharge.

There still remain two points to be considered and determined before the scheme may be regarded as complete, viz., (1) the means of overflow for storm-water, (2) the rising-main and pumps for raising the sewage. It is required to lift the sewage at the maximum rate of 3,338 cubic feet per minute from the bottom of the sump, say 5 feet below ordnance datum, to the soffit of the gravitation trunk-sewer, a height of 56·10 feet. The sewer to be filled is 4 feet 9 inches in diameter, but it is, of course, unnecessary to make the rising-main of equal cross-sectional area; greater efficiency will be obtained by pumping at a higher velocity through delivery-pipes of smaller bore. For the purposes of these notes the Author has assumed that the rising-main shall consist of cast-iron pipes about 2 feet 6 inches in diameter, with an additional line of pipes alongside for ultimate requirements. The pipes will be laid a few feet below the surface of the ground, along the level to the foot of the hill, then rising quickly by following the natural slope of the ground until the level of the gravitation-sewer is reached. It will be seen that in the particular instance under consideration the rising-mains cross a tidal river. This entails the construction of a form of inverted siphon so that a minimum headway of 6 feet may be obtained above high-water of ordinary spring-tides. The rising-mains laid down will be capable of dealing with the full capacity of the sewer, which is designed to meet the demands of the next 30 years, but it is obviously unnecessary to provide pumps of that capacity at present. It will at once appear that the correct plan is to provide pumps equal to the requirements of the immediate future, additional plant being laid down as occasion arises. Allowing for a population increasing to, say, 80,000 in the next few years, the pumping-capacity (at the rate of 150 gallons per head per day) will be 8,333 gallons per minute. The length of the rising-main is 1,400 feet, and in this length there will be four bends due to crossing over the River Ely. The net "lift" is 56·10 feet, which, allowing for bends and friction in the pipes, may be taken as 60 feet for working purposes. These requirements would be best satisfied by laying down four pumps, each capable of dealing with a population of 20,000, with two similar pumps extra, "standing by" in case of breakdown. Each pump would then have capacity for raising 2,083 gallons per minute to a height of 60 feet, or about 50 horse-power. Taking the normal dry-weather flow at 20 gallons per head per day, half

discharged in 6 hours, a discharge of 2,083 gallons per minute represents a population of 75,000, so that until the population served by the sewer exceeds that number one pump will be sufficient for dealing with the dry-weather flow, the other pumps coming into action successively as the sewer is filled by increasing rainfall. As the district outgrows the capacity of the pumps provided, additional plant will, of course, be required, and the second line of delivery-pipes, already laid down, will come into use. Similar arrangements will have to be made for dealing with the storm-water overflow. The ultimate maximum overflow will be the total discharging-capacity of the 6-foot sewer, less the amount pumped to the 4 feet 9 inches sewer, which gravitates to the outfall at Lavernock. The storm-water overflow is into a tidal river, discharging at about mean tide-level, and, as overflow may occur at any state of the tide, the pumps must be capable of discharging against the highest tide. The height of extraordinary tides is 27 feet above ordnance datum, and therefore, allowing 5 feet for the depth of the sump, the pumps must have a "lift" of not less than 32 feet. In deference to the request of the owners of land along the banks of the river, it is proposed to discharge the overflow through a screen of $\frac{3}{4}$-inch mesh. It is intended that the existing outfall shall also be utilized as a storm-water overflow when the tide will allow.

An item that has not yet been referred to, but which must be considered, is provision of access to the sewers, and of means of ventilation. Access to the sewers from the surface should be gained through man-holes, conveniently placed. A man-hole should be constructed at every junction of the sewer with another. In the case of the sewers which carry storm-water, man-holes should be constructed at frequent intervals, so that, in the event of men being in the sewers when a sudden rainfall occurs and the sewers quickly fill, the men will not have far to travel to find egress. The distance between man-holes along the intercepting-sewers, which are comparatively small, should not exceed 80 yards. In the case of the 6-foot main-culvert, in which a man can walk upright, the distance may be increased to 100 yards. The greatest distance which a man would have to traverse to the nearest man-hole would thus be 40 yards and 50 yards respectively. In the trunk-sewer, between the storm-water overflow and the outfall, it will hardly be necessary to provide man-holes at more frequent intervals than 200 yards apart. The situation of the man-holes will depend largely upon the route followed by the sewer, a circumstance which will be better appreciated on reference to the

longitudinal section (Fig. 4, Plate 9), on which are indicated positions that suggest themselves as suitable sites for man-holes. Where the sewer is in a tunnel the shafts sunk for the purposes of excavating are utilized for building up man-holes.

For a large trunk-sewer with a good volume flowing through at self-cleansing gradients, there should be little difficulty in providing efficient natural ventilation. The route is through open country, and free discharge of air at the surface will be inoffensive. Therefore each man-hole may act as a ventilating-shaft, with a grating at the surface, and, in the Author's opinion, it yet remains to be proved that this method is not generally the most effective.

Details of construction hardly enter within the scope of these notes, but it may be observed that the sewers should be constructed of hard brindle or vitrified bricks, to resist attrition, with cement-mortar joints, flush with the brickwork inside. The inside surface of the sewer should be as smooth as possible in order to retard the flow of sewage to the least extent. The thickness of brickwork will be 18 inches in the 13-foot sewer, 14 inches in the 6-foot sewer, and 9 inches in the remaining sewers, except where the route is under railways, with the sewer comparatively near the surface, where the thickness will be 18 inches. The cast-iron pipes should have flanged and faced joints, with the exception of those below low-water level, which should be turned and bored. It is proposed to carry out the work in open cutting until the depth to the invert exceeds 25 feet, when tunnelling will be resorted to.

The engineer responsible for the scheme on which these notes are based is Mr. William Harpur, M. Inst. C.E., the Borough Engineer of Cardiff.

The Paper is accompanied by drawings, from which Plate 9 and the Figures in the text have been prepared; and by Tables of rainfalls at Ely Pumping-station and Cogan Reservoir, in the County of Glamorgan, during 1891–1900, which may be seen in the Library of the Institution.

(*Students' Paper No. 497.*)[1]

"Notes on the Construction and Setting-out of Tunnels in the London Clay."

By Hardington Arthur Bartlett, Stud. Inst. C.E.

At the present time there is great activity in the construction of tunnels by what is known as the Greathead method, for underground electric railways in London. In the following Paper are described in detail several of the operations involved in such work, as exemplified in the construction of the Baker Street and Waterloo Railway.[2]

The Street Main Traverse Survey.

The main survey was carried out entirely by night, owing to the traffic in the day-time being too heavy to permit of the survey being made. Two complete surveys were made, independent of each other, one by the engineers and the other by the contractors, so as to provide a check. Permission was obtained, from the various Vestries through which the line passes, for the insertion of pavement-marks or road-boxes at the end of each survey-line. The pavement-marks consisted of steel blocks 2½ inches in diameter at the top, tapering to 1½ inch in diameter at the bottom, and 1½ inch in depth. These blocks were set in neat cement, and a centre-punch mark was made in the centre of each. In a few instances it was found necessary to have the points in the road, in which case a road-box of the usual form was employed; under the road-box a large wooden peg was let into the concrete foundation of the road and cemented, a large flat-headed nail having a punch-mark

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[1] Paper read and discussed before a Students' Meeting at the Institution on 13 February, 1903.

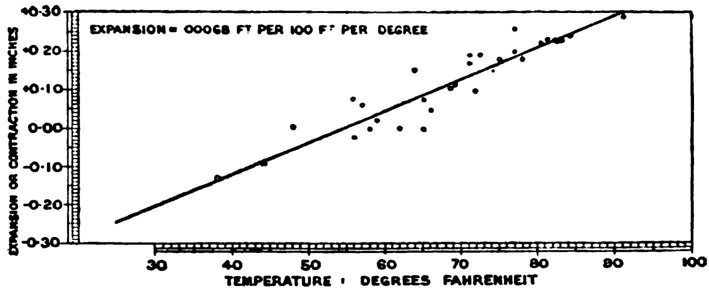
[2] For a general description of the route of this railway, and a particular account of the construction, under air-pressure, of the section under the River Thames, *vide* "Subaqueous Tunnelling through the Thames Gravel," by A. H. Haigh, B.Sc., M. Inst. C.E.—Minutes of Proceedings Inst. C.E., vol. cl, p. 25.

in its centre being driven into the top. Special instruments of great precision were constructed for this work, the angles being read to single seconds.

The tapes were tested every night before being used, and the temperature at which each line was chained was observed. Two tapes were employed in order to eliminate as much as possible the error due to marking, one tape being held in position until the other was brought forward and placed against it; this operation was continued to the end of the line. The tapes were stretched with a uniform pull of 28 lbs., applied by means of a spring-balance, as it was found that an appreciable difference could be made in the measurements by slightly varying the pull. Whenever it was possible to see directly on to the station-point, a chaining-arrow was held on it in front of an oil-lamp having an opalite glass front, or one of ordinary glass covered with tracing-cloth to diffuse the light. When the distance was too great for the arrow to be seen, a rod ½ inch square having a sharp steel point was used. In a few instances it was impossible to see directly on to the mark, and in these cases a plumb-bob was suspended from a tripod placed over it; on the line of the plumb-bob was threaded a brass bar, behind which the lamp was held. These brass bars varied in length between about 2½ inches and 4 inches, and in thickness between ¼ inch and ¾ inch, depending on the distance of the point from the theodolite. The chaining was carried straight forward along the streets, and levels were taken at every 100 feet, and at intermediate points where necessary, corrections being afterwards made for these levels. The effect of temperature on the tape had, of course, to be taken into account, as the lines were chained at widely different temperatures. A long series of very carefully conducted tests, numbering in all more than one hundred, was made, with various steel tapes, in order to arrive at the true coefficient of expansion. The tests were carried out at the Standard in Trafalgar Square, with seven steel tapes, of which three were ⅜-inch, and three ½-inch 100-foot tapes, and one a ⅜-inch 50-foot tape. The temperatures were taken with three thermometers (one of which was a very sensitive chemical thermometer), which were compared with a standard thermometer before each series of tests was made, and each night before chaining was commenced. The temperatures of the air, of the tape, and of the ground were taken; when the tape was in direct sunlight the temperature was taken by laying the thermometer on it when it was hot, the thermometer being shaded from the direct rays of the sun. The tape was also dragged for some distance along th

pavement to ascertain whether friction had any effect upon it, but the effect was inappreciable. The results of the observations were plotted upon a diagram, in which temperatures were represented by abscissas, and alterations in length by ordinates, *Fig. 1.* A line representing the average expansion was then drawn, and from this the increase or decrease in length at any temperature can be found. From this diagram the expansion or contraction of a 100-foot tape, due to change of temperature, was ascertained to be 0·00068 foot per 1° F. It may be observed that this result

Fig. 1.



RESULTS OF EXPERIMENTS ON EXPANSION OF STEEL TAPES.

corresponds with that obtained by Lavoisier for tempered steel. As an example, showing the importance of the effect of temperature, it may be mentioned that on one line of only 481·795 feet in length, the error due to temperature was 0·08 foot, or just 1 inch. The longest line chained was 1,622 feet, and the shortest line 375 feet in length. The angles were all read, on an average, six times by the contractors and six times by the engineers, and the greatest difference between the means of the observations for any angle was 3 seconds.

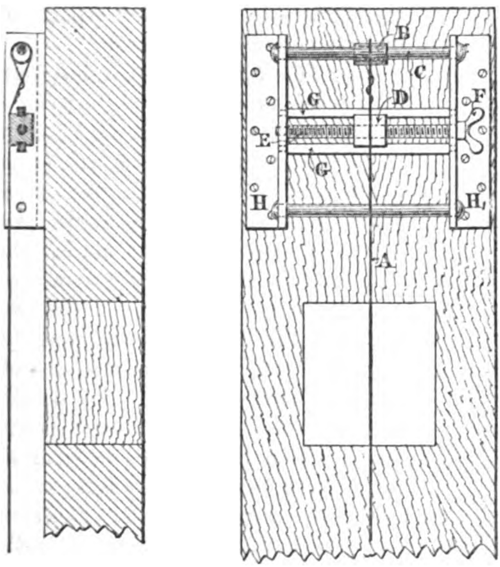
CONNECTION BETWEEN STREET TRAVERSE-SURVEY AND TUNNEL-LINES.

The method of connecting the surface survey with the tunnel-lines depends upon the position of the working shaft relatively to the centre-line of the tunnel. The following are two typical cases:—

Case I.—Shaft sunk on centre-line of Tunnel.—Two points were taken on the surface, on the centre-line of the tunnel, about 1,000 feet apart. The shaft was sunk on this centre-line between the two points and about 210 feet from the nearer point, at

which the instrument was set up. Two wires were suspended in the shaft, 15 feet apart, and were aligned with the instrument. Steel pianoforte-wire was used, the wire nearer to the instrument being of No. 24 standard wire-gauge, and the other of No. 16 standard wire-gauge. From each of the wires heavy weights were suspended, swinging in pails of oil, the weight on the thicker wire being 56 lbs. and that on the thinner wire about 30 lbs. Special traversing-frames were made, with which to adjust the wires. One of these is shown in *Figs. 2.* The wire A is

Figs. 2.

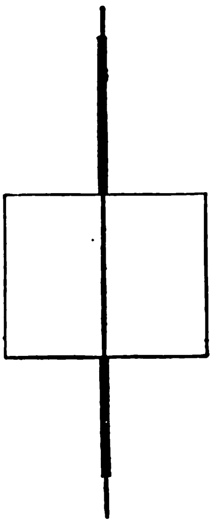


DETAIL OF TRAVERSING SCREWS
Scale 1 Inch = 1 Foot

made fast to the sleeve B, which slides on the bar C. The wire rests in a small groove cut in the adjusting-block D, which is worked backwards and forwards between the guides G G, by means of the screw E and the butterfly-nut F. H and H_1 are angle-bars firmly fixed to the timber framing. The wire is adjusted to line by turning the butterfly-nut. The instrument having been sighted on the far point and clamped, the nearer wire was brought into the field of sight and was carefully adjusted in line. A sheet of white paper was then placed behind it, and the farther wire was

brought into line and adjusted until it appeared as shown in *Fig. 3*, the thicker wire showing on either side of the thin wire, at the edge of the white paper. This was found to be the most satisfactory method. The alignment of the wires was checked a dozen times before the points underground were finally settled upon. As a length of 3,000 feet had in this instance to be driven from the base-line of 15 feet in the shaft, any error in the alignment of the wires would be magnified 200 times; thus an error of $\frac{1}{10}$ inch in the position of the wires would give an error of 20 inches at the end of the line. As a matter of fact, however, the two shields met on this length within $\frac{1}{8}$ inch in respect of line, and exactly coinciding in level.

Fig. 3.



WIRES AS SEEN THROUGH INSTRUMENT

Case II.—Shaft about 80 feet from centre-line of Tunnel, at a curve of 5 chains radius.—A service-tunnel 8 feet in diameter was driven from the shaft to the tunnel, through which a straight line could be run connecting the shaft and the main tunnel. A plan was prepared showing the shaft, the service-tunnel, the main-tunnel and the traverse survey-lines. On this plan the straight line through the service-tunnel was plotted and produced until it intersected one of the main traverse survey-lines. The distance of the intersection from the station-point, and the angle which the line made with the survey-line, were scaled off; this point was set out on the ground; and the line across the shaft was set out by turning the angle as scaled on the drawing. On this line the two wires were suspended in the shaft as described in *Case 1.* The instrument was then set up in the centre of the main tunnel and was adjusted so as to bring it in line with the two wires. The point so obtained was the first station-point in the tunnel, and with the aid of the instrument a point was also marked on the farther side of the shaft on the same line. With the line between these two points as base, all the angles and lines for the tunnel were set out in the usual way.

TUNNELLING WITH A SHIELD IN THE LONDON CLAY.

The Greathead shield consists of three main parts, viz., the cutting edge, the skin, and the cylindrical jack-casting.

The cutting-edge is of cast steel, is constructed of three sections bolted together, and is of slightly larger diameter than the skin of the shield, in order to facilitate the progress of the shield through the clay.

The skin consists of a cylinder, 6 feet in length, built of ½-inch steel plates, in three sections, with butt-joints and ½-inch cover-plates, extending from the cutting-edge, to which it is fastened by means of countersunk set-screws, to about 2 feet 9 inches behind the back of the jack-castings, forming what is known as the "tail" of the shield. The object of the tail is to support the ground and to protect the miners whilst erecting the tunnel-lining.

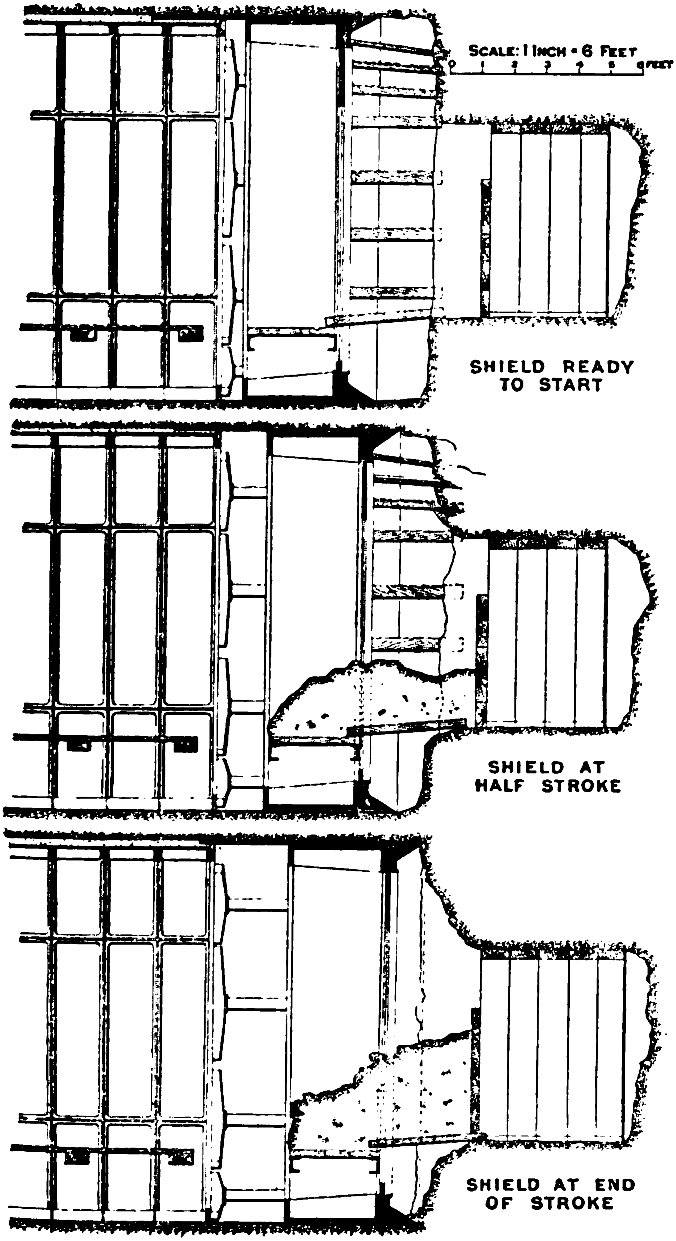
The ring of jack-castings is made in six sections bolted to one another and to the skin and cutting-edge, hard-wood packings being inserted in the horizontal joints. Besides affording a firm foundation for the jacks, these castings greatly strengthen the shield, and indeed are its chief support. Between the jack-castings and the cutting-edge is a steel diaphragm consisting of two ½-inch plates, the duty of which is to give stiffness to the shield and to maintain it in shape.

The shield is driven forward by eight hydraulic rams or jacks, each 7 inches in diameter, the requisite pressure being obtained by means of an air-engine or intensifier, fixed to the shield, which is supplied with air at a pressure of 60 lbs. per square inch, and which intensifies the pressure, forcing water into the rams at a pressure of 1 ton per square inch. A flexible pipe connects the compressed-air main in the tunnel with the shield, and the intensifier draws its water from two tanks fixed on the shield, one on either side. The shield is fitted with an oak grouting-rib, made in sections, having strips of leather nailed to its outer edge, and projecting about ½ inch beyond the oak all round. This ring is held in position by the rams and serves to keep the grout in, and to distribute the pressure of the rams evenly over the segments of the tunnel-lining.

The following is the cycle of operations in working a shield:—A box-heading is driven in advance of the shield, being always kept about 6 feet to 8 feet ahead of it, and is timbered with 4-inch head- and side-trees. The height of the heading is 6 feet, and the width varies between 5 feet and 6 feet. Two miners and two

labourers work continuously in the heading, even whilst the shield is in motion, and can just keep pace with it. Commencing with the shield ready to be moved forward, the last ring erected has been grouted up, the grouting-ribs being held in position by the rams. The clay has been roughly trimmed to the shape of the cutting-edge for a distance of about 20 inches ahead of the shield, and the piles, consisting of boards, 6 inches by 1¼ inch by 3 feet in length, sharpened to a point and shod with iron at one end, have been placed in position. The number of piles used varies with the nature of the ground, and their duty is to bring down the greater part of the clay for the next ring as the shield goes forward. A small pocket is formed for one end of each pile, just sufficiently large to support the end and to hold it in position until the shield starts. The first two settings of the heading are knocked away and laid across the entrance to the heading to keep the clay from falling into it as it is brought down by the piles. Planks are laid from the heading to the platform of the shield, to keep the loose clay from falling into the invert. The shield is stopped at half-stroke if going round a sharp curve, in order to check its position, but otherwise it is given the full stroke of 20 inches without stopping. The work done in one stroke of the shield is illustrated in *Figs. 4.* The shield having reached the end of its stroke the rams are drawn back, the grouting-ribs are removed, and the invert of the tail of the shield is cleaned out ready for the tunnel segments. Whilst the shield is going forward, the cast-iron segments for the ring, with the necessary bolts and packings, are brought forward on trolleys. The two bottom segments are placed in position on the skin, and are bolted to the last ring erected, packings having been inserted between them and the ring. The packings are of creosoted deal, and are cut to the shape of the segments, with holes bored for the bolts. They vary in thickness from ⅜ inch upwards, thicker packings being necessary when going round curves. The next two segments, the "side plates," are then lifted into position on the bottom plates, and are similarly bolted to the last ring. Meanwhile, two miners, using the heap of clay in front of the shield as a platform, have been trimming off the clay round the upper half of the cutting-edge for a distance of 20 inches ahead of it, and replacing the piles in position ready for the next advance. A temporary stage, about 4 feet above rail-level, is erected, and the top segments and the key are lifted into position and temporarily propped, being forced about 1 inch higher than their final position, in order to allow sufficient clearance for fixing the key. When the key is in position,

Figs. 4.


SCALE: 1 INCH = 6 FEET
0 1 2 3 4 5 6 FEET
SHIELD READY TO START
SHIELD AT HALF STROKE
SHIELD AT END OF STROKE

the temporary props are removed, the packings are inserted, and the whole ring is bolted up. The remaining sections of the grouting-rib are then placed in position and the rams are forced out to hold them. The ring is then thoroughly grouted with lime or cement under a pressure of 60 lbs. per square inch. As soon as the ring is bolted up, the temporary stage is removed, and the clay brought down by the piles is filled into skips and run back to the shaft. When all the loose clay has been removed, the miners trim off the clay in the invert ahead of the shield, and the first two settings of the box-heading are knocked away preparatory to the next stroke of the shield.

Method of Guiding a Shield.—Two sets of apparatus are used for guiding a shield, in order to control its movement, in respect of (1) line, and (2) level.

(1) Its movement in respect of line is controlled as follows:—Two plumb-lines are suspended from the top of the tunnel, about 30 feet apart, the forward line being about 12 feet from the shield. These two lines are hung exactly on the centre-line of the tunnel if on a straight, or on the tangent-line if the tunnel is on a curve. The shield is fitted with a removable centre-rod, which can be fixed in two brackets on the back of the shield. On this centre-rod a saw-cut is made, exactly in the centre. In order to test the shield for position in line, the two plumb-lines are allowed to hang in the tunnel, and the centre-rod is placed in position in the shield. If the saw-cut on the centre-rod is in exact alignment with the two plumb-lines, the shield is in its correct position as to line; if it is found to be out of line, it must be brought right again by using more rams on one side than on the other. When going round a curve, a table of offsets for every foot of length is compiled. A mark is made on the centre-rod, at a distance from the centre saw-cut equal to the offset for the particular point as given in the table, and this mark is brought into alignment with the plumb-lines.

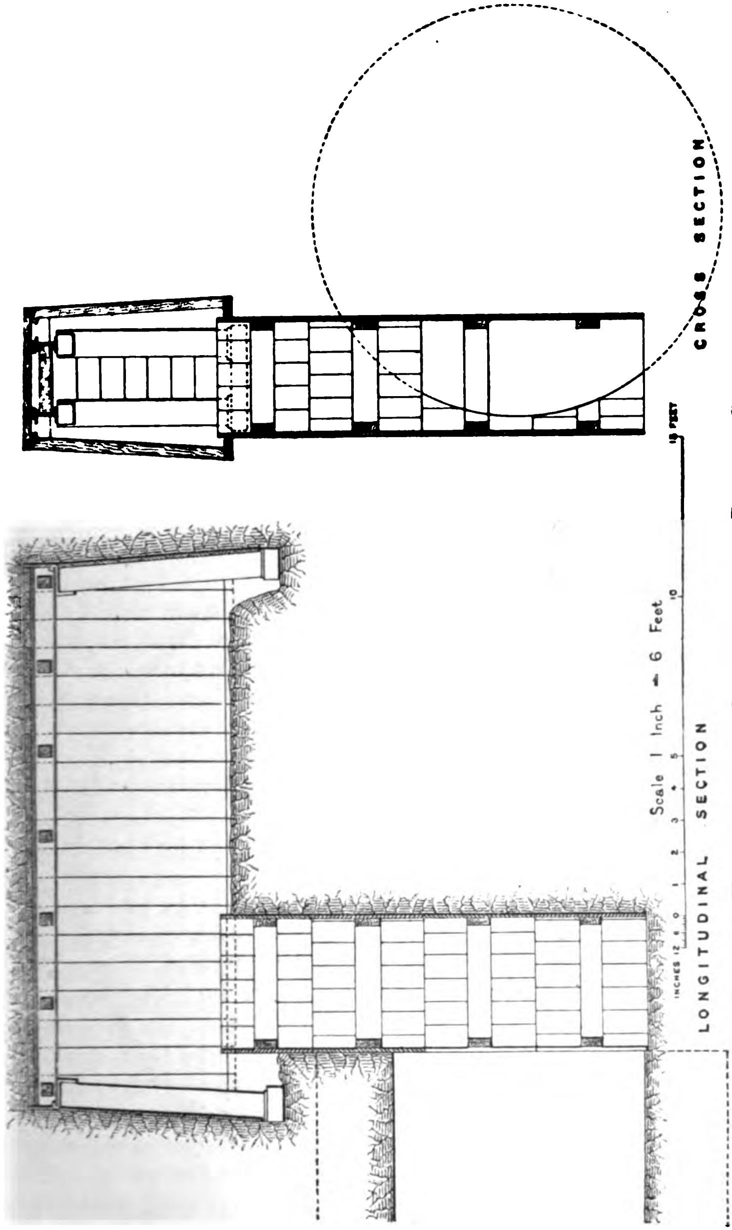
(2) For checking the position of the shield in respect of level, two adjustable boning-rods are bolted to the roof of the tunnel, about 30 feet apart, the forward rod being about 10 feet from the shield. The cross-pieces on these rods are adjusted to the required height by means of a level, and a fixed mark is made on the shield. If the shield is at its correct level this mark should be exactly in alignment with the tops of the two cross-pieces in the tunnel. If it is not, the level of the shield must be adjusted by putting more power on the top or bottom rams as required. In a method of guiding the shield introduced by Mr. H. H. Dalrymple-Hay,

M. Inst. C.E., two guide-rods, each about 25 feet in length, are fixed to the shield on its horizontal diameter, one at each side. These guide-rods are graduated in feet and inches, and are drawn forward by the shield past two "zero-pieces" or indexes fixed to the sides of the tunnel. As the shield advances, the readings at these two indexes should, of course, be the same. If they differ, one side of the shield is gaining on the other, and the shield is going "off-line." For going round curves, a special shrunk scale is calculated for the inner side of the curve and marked on the inner guide-rod, so that the shield is guided on the curve by keeping the scale-readings the same on both sides of the tunnel. With methods such as these it is fairly easy to keep the shield within 1 inch of its correct position.

The Construction of a Break-up Chamber.—In tunnelling by the Greathead method, it is necessary to enlarge the tunnels on curves, or at stations or cross-overs. A separate shield has to be used for each size of tunnel; consequently, when the size has to be altered a new shield has to be built. This is done by constructing by hand a short length of tunnel, of a size sufficiently large to take the shield and to allow of access to the outside of the skin-plate for the purpose of bolting together the various segments. This short length of tunnel is known as a "break-up chamber," and is 10 feet to 12 feet in length. The construction of a break-up chamber is one of the most difficult operations in connection with this system of tunnelling. The following is a description of the method employed in constructing a break-up 26 feet in internal diameter, in which to erect a shield 22 feet 10 inches in diameter, for driving a station-tunnel of 21 feet 2½ inches internal diameter. A vertical box-heading or shaft, usually 4 feet 6 inches by 3 feet 9 inches, is first driven upwards from the front of the small shield, on the centre-line of the proposed break-up, and is close-timbered all the way up. It is driven in 3-foot 6-inch lengths, the miner working at the clay above his head, and is timbered with poling-boards and walings to within about 6 feet of the top, the last 6 feet being taken out at one time; the roof is then supported by head-trees, carried on side-trees which rest on foot-blocks. From the top of the shaft a horizontal heading is driven in the usual way for the full length of the break-up, and timbered. When the heading is completed, the first two crown-bars, consisting of rolled steel joists, are got into the heading and propped off "stump-props." These props are provided with specially designed cut and bent plates which prevent them from being pushed inwards when the weight of the ground comes upon

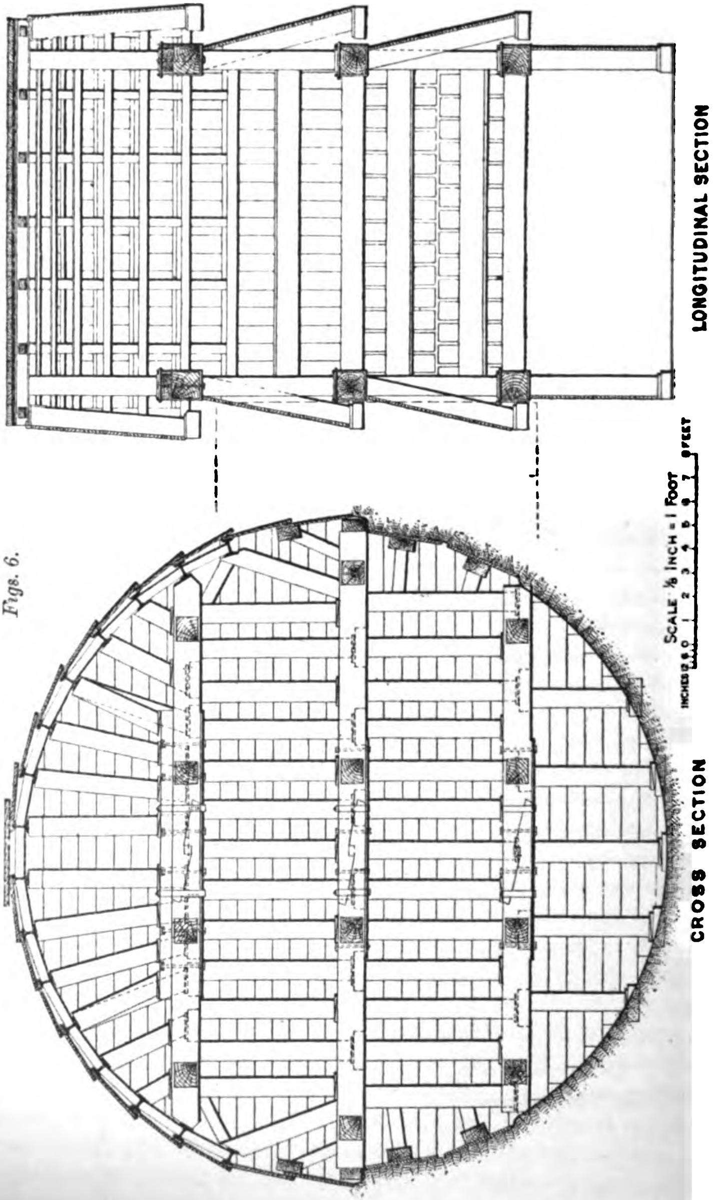
them. The two faces of the heading are timbered with creosoted poling-boards, wedged tight from the stump- or ground-props, which are given a slight rake and rest on half-timber foot-blocks, being driven up tight to take the weight by means of oak folding-wedges. The crown-bars are chogged apart with seven hardwood chogs, *Figs. 5*. The top weight being thus taken by the crown-bars and props, the side-trees are knocked away and the ground is excavated on both sides of the heading for its full length, to a distance of about 2 feet 6 inches. The top is timbered with creosoted poling-boards 3 feet in length, one end of each board resting on the crown-bar, and the other temporarily propped on a vertical poling-board, which also serves to hold the sides of the excavation. Two more crown-bars are then got into the heading and propped as before with ground-props. This operation is repeated until ten bars are in position. Each pair of bars is grouted up as it is placed in position. The two top-cills are then got in. These are made in two pieces scarfed together. The scarf is made as shown in *Figs. 6*, with a wrought-iron plate at the bottom and a saddle-piece on top, and the whole is fixed with wrought-iron straps and bolts. These cills are placed in front of the ground-props and level with the foot-blocks, one at each end of the break-up, 12 feet 6 inches apart. The cills are stretched apart with stretchers, and the weight of the roof is then transferred to the cills by means of front-props, each of which is wedged up tight with a pair of oak wedges. As soon as this is done the "second lift" is commenced, by excavating a trench between the two centre-cill stretchers for the full length of the break-up. Two back-props are then put in at each end of the trench to take the weight of the cills above, and are wedged up from foot-blocks as before. The trench is then widened out at both sides simultaneously, and back-props are put in as for the first lift, together with the remaining crown-bars which come below the top-cill. When the second row of back-props is in position, the second pair of cills is got in as before and stretched apart, and the weight of the top-cills is taken by a row of vertical props. The third lift is excavated in the same way, which brings the break-up to within about 6 feet of the bottom, at the centre. In the bottom lift, front-props only are put in, and the clay round the lower half of the break-up is then trimmed off to the sweep of the iron lining, *Figs. 6*. The next step is to fix the iron lining. The segments are brought into the break-up one at a time, and are placed in position and bolted up, the rings being arranged so as to break joint. The whole of the lining for the bottom half, or up to springing-level, is

Figs. 5.



HEADINGS FOR THE CONSTRUCTION OF A BREAK-UP CHAMBER.

Figs. 6.



TIMBERING OF A BREAK-UP CHAMBER.

got in and grouted up. Two of the rings are then carried round and completed, and the space between the outside of the iron and the crown-bars and poling-boards is filled with Portland-cement concrete, and the two rings are then thoroughly grouted up. The remaining six rings are then completed, one at a time, each ring being grouted up as finished. The clearance allowed between the iron lining and the cills is 3 inches at each end, and between the top of the outside of the lining and the underside of the crown-bars 2 inches. The iron for the break-up consists of eight rings of cast-iron segments, each ring being 26 feet in internal diameter, 28 feet in external diameter, and 1 foot 6 inches in length, and consisting of fourteen segments and a key. Creosoted deal packings are used in the circumferential joints.

Headwalls.—Headwalls, of brickwork in cement, are built to support the two faces of the break-up. Where the tunnel which runs into the break-up is small, the usual thickness of the headwalls is 3 feet 9 inches, and where a large tunnel connects with the break-up the thickness is 3 feet. These headwalls have to be built by undercutting the clay. The bottom-cills are temporarily strutted with raking-struts, and the props supporting the cills are then cut out and removed, leaving the face of the clay exposed, up to the level of the bottom-cill; the ground is then got out to the required depth, and is temporarily timbered to hold it whilst the brickwork is put in, which is at once proceeded with, and when complete it is well grouted up under air-pressure. The second row of cills is then strutted with raking-struts, and the bottom-cills are removed with the face-timbering as before, and the brickwork continued on that already in. These operations are continued until the whole of the face-timber has been removed and replaced by brickwork. Four-ring brick eyes are turned round the tunnel-openings in the headwalls, that at the forward end of the break-up being large enough for the station-tunnel shield to pass through, allowing 2 inches clearance. The exposed face of the clay inside the eye is carefully timbered, the break-up is cleared out and the cast-iron segments are filled with concrete. Iron runners are placed in the bottom of the break-up, on which the shield, when erected, can glide forward without obstruction.

Force Required to Drive a Shield.—The figures given in the Appendix, which have been taken from actual observations, are intended to afford an indication of the force required to drive a shield in tunnelling in London clay. The first three sets of observations apply to a shield 13 feet 5¾ inches in diameter,

and the remainder to a shield 22 feet 10 inches in diameter. In the case of the larger shield, the back-pressure exerted by the six table-rams, each 7 inches in diameter, has to be deducted. The pressure in these rams was 890 lbs. per square inch.

The Author was Engineer for the contractors, Messrs. Perry and Company, on the Baker Street and Waterloo Railway.

The Paper is accompanied by eleven tracings, from which the Figures in the text have been prepared.

[APPENDIX.

APPENDIX.

FORCE REQUIRED TO DRIVE A SHIELD IN TUNNELLING THROUGH LONDON CLAY.

Diameter of Shield.	Circumference of Shield.	Number of Rams.	Diameter of Rams.	Pressure in Rams.	Total Forward Pressure.	Total Back Pressure.	Resultant Forward Pressure.	Pressure per Foot-Run of Cutting-Edge.	Remarks.
Ft. Ins.	Feet.		Inches.	Lbs. per Sq. In.	Tons.	Tons.	Tons.	Tons.	
13 5⅜	42·3	8	7	2,240	307·8	..	307·8	7·3	Maximum obtainable.
		6	7	1,680	173·1	..	173·1	4·1	Piles used.
		8	7	1,800	247·4	..	247·4	5·8	Piles used.
22 10	71·75	22	7	2,240	847·0	..	847·0	11·8	Maximum obtainable.
		15	7	1,176	303·0	91·8	211·2	2·9	No piles used.
		16	7	1,170	321·6	91·8	229·8	3·1	
		18	7	1,150	356·4	91·8	264·6	3·7	
		19	7	1,100	359·1	91·8	267·3	3·7	Piles used.
		19	7	1,145	374·3	91·8	282·5	3·9	
		20	7	1,000	344·0	91·8	252·2	3·5	
		20	7	1,160	400·0	91·8	308·2	4·3	

(*Students' Paper No. 501.*)[1]

"Bacterial Sewage-Disposal Works at Ash, Dover."

By Hugh Sextus Watson, Stud. Inst. C.E.

The village of Ash, near Dover, has a population of about 1,400 inhabitants. The works described in the following Paper, however, cannot be taken as in any way typical of a well-designed installation for the disposal of the sewage from a village of this size, on account of the special circumstances which attended their construction.

In the first place, there were already existing works that had been designed to treat the sewage by methods differing widely in principle from the bacterial process, and it was desired to utilize as much of these works as could conveniently be retained without prejudicial effects. In the second place, the governing factor was the sewage itself, which was of such a nature as to necessitate very special precautions being taken; this was caused by the presence of a brewery, a circumstance of no significance in a large town where the brewery-refuse constitutes only a small part of the whole sewage to be treated, but a most important consideration when the refuse from this source has to be regarded as the main contributor to the sewers, constituting 60 per cent. of the total sewage, and so overwhelming the domestic sewage in quantity as well as in strength.

An experiment of treating the sewage by aerobic contact-beds was commenced in the spring of 1899, when the works were handed over for the purpose to Messrs. F. H. Anson and H. C. H. Shenton, the Engineers for the scheme which forms the subject of this Paper. The works at that time consisted of three high-level tanks, each 25 feet by 25 feet, by 5 feet 6 inches in depth at the sides, sloping to 6 feet 6 inches in depth at the centre line, al... a channel 1 foot in width and 6 inches in depth;

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[1] ... discussed before a Students' Meeting at the Institution on

and four low-level tanks, each 15 feet by 15 feet and of the same depths and construction as the high-level tanks. The three high-level tanks were discharged by means of 6-inch hand-valves into an open channel, by which the effluent was conveyed to the lower tanks. From these it was discharged by hand-valves into a 6-inch drain and conveyed directly into the Durlock stream, which constituted the lower boundary of the works. The effluent from the high-level tanks could also be conveyed on to the specially-prepared irrigation-land. This, however, proved quite unsuitable for purification purposes, as it consisted of a peaty soil upon a subsoil of clay, whilst the drains, which constituted an elaborate system of sub-drainage, had been laid in the clay, so that they were useless for the purpose of drainage. Two of the high-level tanks were at once adapted to form first-contact bacteria-beds, whilst the four low-level tanks were similarly adapted to form second-contact beds for experimental purposes. The filling material of one of the first-contact beds consisted of 6 inches thickness of large boulders, in which were embedded rows of 3-inch open-jointed drain-pipes 5 feet apart; on this was laid 3 feet thickness of coke in 1-inch pieces, the top being finished off with 6 inches thickness of fine gravel. In the other bed the 3 feet depth of coke consisted of ¾-inch pieces. Three of the second-contact beds were similarly filled with ¾-inch material, and the fourth with ½-inch material, the top and bottom 6 inches being the same in all the beds. The covering of fine gravel was intended to act as a screen to prevent solid matter getting into the body of the bed, on the principle of the Roscoe filters at Manchester. Nine 6-inch vertical pipes were placed in each bed, with the view of providing proper aeration. These beds were worked continuously, from April 1899 until July 1902.

The average daily dry-weather flow amounted to about 18,000 gallons, of which about 12,500 gallons came down between the hours of 6 A.M. and 5 P.M., at an average rate of 1,150 gallons per hour, and was treated upon the beds; the remaining 5,500 gallons came during the night and was stored in the third high-level tank and afterwards treated upon the land. As the original capacity of each of the first-contact beds was about 5,500 gallons, it will be seen that each would only be filled once during this time. This means that each bed took about 5½ hours to fill, which experience has shown to be fatal, causing a bed to become foul and choked; it had also the disadvantage of unequal contact. A bed when ful was allowed to stand for 2 hours; emptying was then commenced and took another hour, making the total time involved in one fill-

ing $8\frac{1}{2}$ hours. Comparing this with what is generally regarded as the best arrangement for working a contact-bed, viz., 1 hour for filling, 2 hours resting full, 1 hour emptying, or a total of 4 hours, it will be seen that the time required to fill a bed once would have been sufficient for two fillings under proper conditions. The Local Government Board regulations state that beds worked by hand may not be filled oftener than twice a day. The only screening done before the sewage passed on to the first-contact beds was by means of a screen, of $\frac{3}{8}$-inch mesh, placed in a manhole upon the main outfall-sewer to collect waste paper, etc., that might find its way down the sewer.

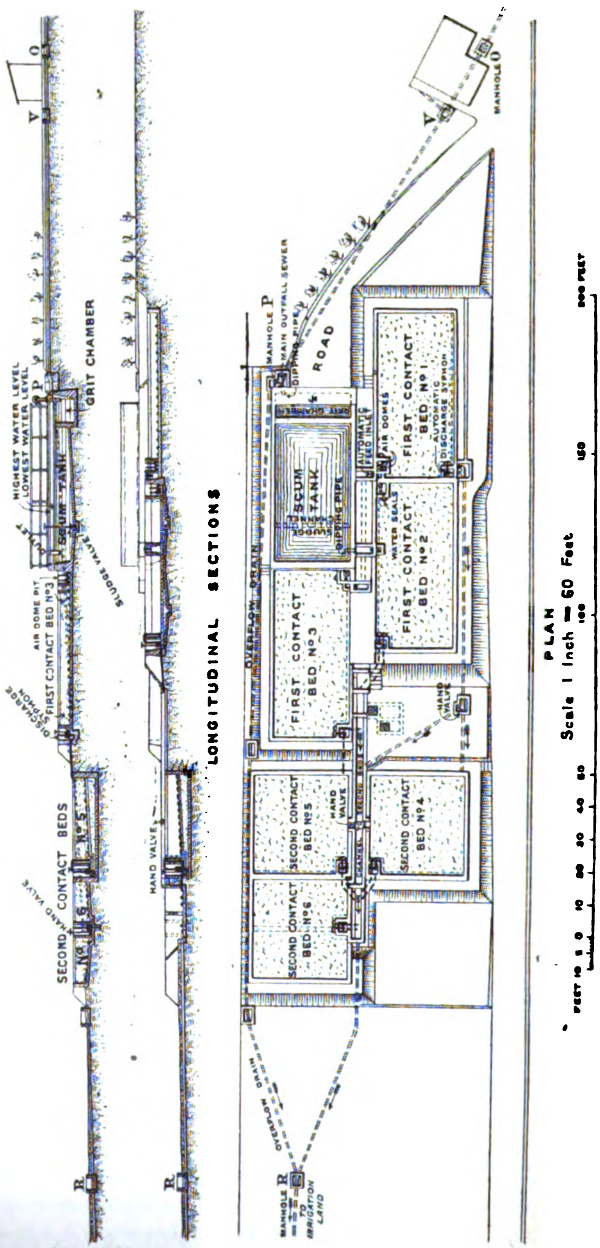
The original liquid capacity of a bed filled with 1-inch material was about one-third of the capacity of the bed before the filling material was put in, which in this case would have been about 5,500 gallons. After 5 months' use this bed is stated to have still retained its liquid capacity; whilst the liquid capacity of the bed filled with $\frac{3}{4}$-inch material was reduced to about one-quarter, or 1,375 gallons. When the beds were emptied in July 1902, the coarser bed was found to be badly choked; the material presented a dark reddish-brown colour and had a slightly disagreeable smell; the 6-inch covering of fine gravel had worked its way into the centre of the bed, which was soft and boggy. The finer bed, on the other hand, had not the appearance of being so choked, nor did it smell, except of earth, whilst the material was very much firmer and more compact, the gravel still forming an even covering over the surface. Ultimate tests proved the capacity of the two beds to be identical, viz., 3,160 gallons, showing a reduction from the original capacity of 43 per cent. in the case of the coarse bed and 37 per cent. in the finer bed. That the finer bed should have cleared itself to this extent since August 1899 is accounted for by the fact that the bed had become leaky, so that the man in charge had never more than half filled it; it had, therefore, not been so overworked as formerly. This tends to show that a bed will regain its capacity if allowed to rest. That little in the way of actual purification was being done by either bed was evident from samples taken from the finer bed, but samples taken from the same batch of sewage after it had passed through a second-contact bed showed that it must have been aided by liquefaction having taken place in the first bed to obtain such a result. One of the second-contact beds was thrown out of use shortly after its construction by the breaking of the outlet-valve, which was not replaced; a second of these beds, namely, that

filled with ½-inch material, was used only until it was found that, owing to the diminished liquid-capacity of the first-contact beds, the two remaining second-contact beds were capable of dealing with the effluent; these beds worked continuously throughout the three years. They were found to be fairly clean, having no smell whatever, whilst they retained much of their capacity, and worked well. The tests showed coke to be an unsuitable filling-material, it having become greatly disintegrated in every case, while the top 6 inches of fine gravel had the effect of preventing proper aeration, the vertical pipes provided for this purpose appearing to be of no practical use.

In the design of the present scheme the experimental beds proved of the utmost value in enabling the difficulties experienced to be avoided, as far as possible, and provision to be made to meet the particular exigencies of the case.

The following are the general features of the scheme:—The sewage enters a scum-tank, from which it is discharged on to three first-contact beds, *Figs 1.* From these beds it is passed on to an equal number of second-contact beds, from which it can be passed either on to three third-contact beds or to a specially prepared area of land, *Fig. 5.*

The scum-tank is 51 feet 6 inches in length by 24 feet 3 inches in width, the inlet and outlet being situated at opposite ends of the tank, and each consisting of a 12-inch dipping-pipe. Eight feet from the inlet-end the tank is spanned by an 18-inch cross-wall to form a "grit-chamber" within the tank. The depth of this chamber is 8 feet, while on the other side of the cross-wall the scum-tank proper is 6 feet 6 inches in depth, sloping down to 7 feet 6 inches, 25 feet from the farther end of the tank, at which point a channel, 1 foot in width and 6 inches in depth, runs across the tank. The peculiar section thus obtained is due to one-half of the scum-tank consisting of old work that has been retained. The apparatus adopted to admit sewage from the scum-tank to fill the three first-contact beds and to discharge the effluent from these beds is that known as the Adams automatic apparatus. The filling arrangements are illustrated in *Figs. 2.* Three filling-chambers, B_1 B_2 and B_3, connected with each other and with the scum-tank by a 12-inch cast-iron main, communicate respectively with three feed-pits, C_1, C_2 and C_3 situated in beds Nos. 1, 2 and 3, so that the sewage that enters a pit flows directly on to the bed. The apparatus for admitting sewage from a chamber to a feed-pit consists of an inverted U-shaped box as shown at A_1 A_2 and A_3.

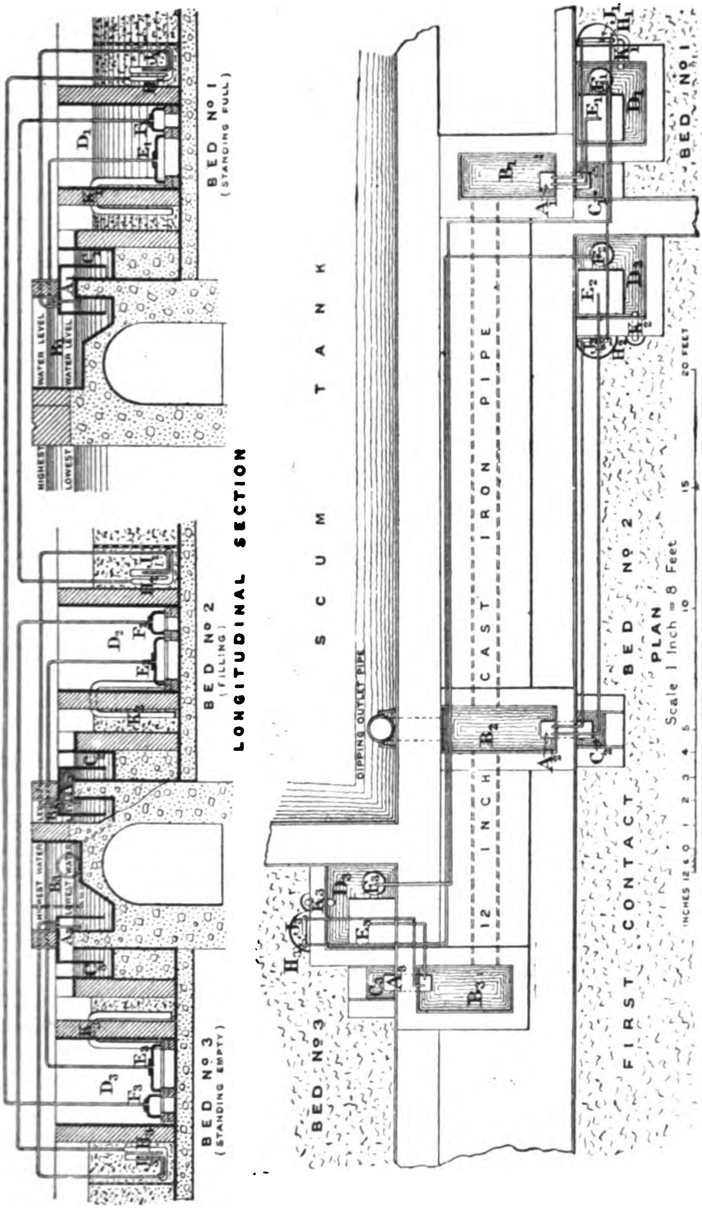


LONGITUDINAL SECTIONS
HIGHEST WATER LEVEL
LOWEST WATER LEVEL
GRIT CHAMBER
SCUM TANK
SLUDGE VALVE
AIR DOME PIT
FIRST CONTACT BED No 3
DISCHARGE SYPHON
SECOND CONTACT BEDS
No 5
No 6
HAND VALVE
P
V
O
R
PLAN
Scale 1 Inch = 60 Feet
FEET 10 5 0 10 20 30 40 50 100 150 200 FEET
MANHOLE O
MANHOLE P
MAIN OUTFALL SEWER
DIPPING PIPE
ROAD
GRIT CHAMBER
AUTOMATIC FEED INLET
AIR DOMES
FIRST CONTACT BED No 1
AUTOMATIC DISCHARGE SYPHON
WATER SEALS
FIRST CONTACT BED No 2
FIRST CONTACT BED No 3
OVERFLOW DRAIN
SECOND CONTACT BED No 5
SECOND CONTACT BED No 4
SECOND CONTACT BED No 6
HAND VALVE
MANHOLE R
TO IRRIGATION LAND

Figs. 1.

Each of these boxes acts as a siphon while the bed with which it

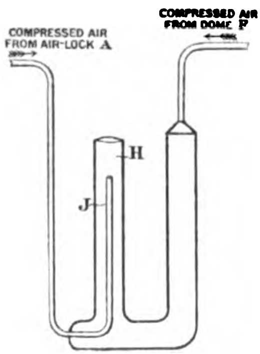
Figs. 2.



is connected is being filled, and at other times as an air-lock to

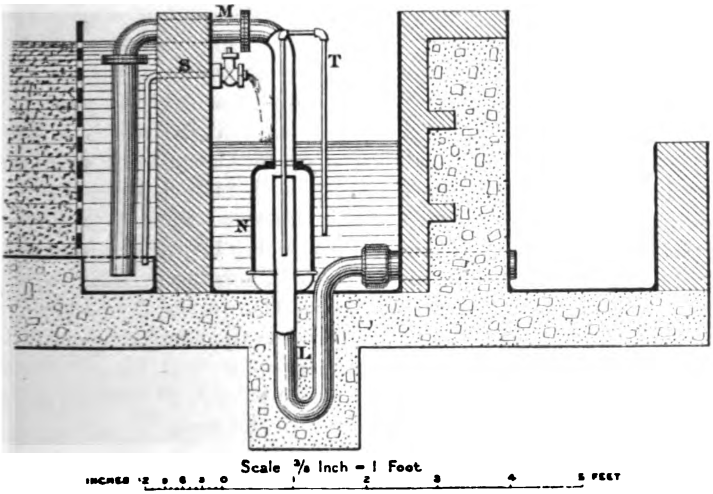
prevent flow of sewage from the filling-chamber to the feed-pit. The air-lock is formed when a bed is filled, as shown in section in the case of bed No. 1; when this bed is nearly full the water from the bed flows through pipe K_1 and fills the pit D_1 containing the air-domes E_1 and F_1. The air compressed in the dome E_1 by the head of water in the pit is conveyed by a pipe to A_1 and forces the air-lock to shut off the sewage from bed No. 1. The air compressed in dome F_1 is conveyed to the outer trap H_2 of the arrangement for starting the filling of bed No. 2. This starting arrangement is shown in detail in *Fig. 3.* It consists of a trap J, the short leg of which is placed within the short leg of the outer and deeper trap H, so that the trap J cannot be forced so long as H is filled. Whilst bed No. 1 is being filled the level of the sewage in the scum-tank and filling-chambers is reduced, but when the flow of sewage to bed No. 1 is cut off by the formation of the air-lock in A_1 the sewage rises till the pressure of air in the air-lock A_2 is sufficient to force trap J_2 and thus free the air in the air-lock and allow A_2 to become a siphon admitting sewage to bed No. 2. When this bed is filled, water from it flows into pit D_2, compressing air in the domes E_2 and F_2, thereby cutting off the flow of sewage to bed No. 2 and forcing trap H_3 of the starting arrangement of bed No. 3, which allows the filling of that bed to commence. When bed No. 3 is full, pit D_3 will fill, and the air in the domes E_3 and F_3 will be compressed; the air from F_3 will force trap H_1 of bed No. 1 (which, in the meantime, has been emptied) and will allow of bed No. 1 being refilled. The starting-traps, H_1 and J_1, H_2 and J_2, and H_3 and J_3, are placed in beds Nos. 1, 2 and 3, so that each time the beds are filled with sewage the traps are recharged, ready for the next filling. The dome-pits, D_1, D_2, and D_3, are emptied as the water is discharged from their respective beds, by the pipes K_1, K_2, and K_3 becoming siphons. Each bed is emptied by means of an arrangement shown in *Fig. 4.* This consists of a siphon M having one leg placed in a sump, to which the drains of the bed discharge, whilst the other leg is placed in a water-tight pit; this leg has sufficient width to surround the inner leg of the draining-trap L and so form an annular siphon N. When a bed has been emptied by this apparatus, some water remains in the sump and in the water-

Fig. 3.



tight pit below the short leg of the siphon T, as well as in the draining-trap L. When the bed is again filled, and the sewage has risen nearly to the surface, the effluent is admitted by the trap S to the water-tight chamber; this trap is so regulated that, before sufficient effluent has entered the chamber to start the emptying siphon M, the two hours allowed for contact have elapsed. The siphon M is set in action when there is a sufficient head of water in the pit to force the trap L and set in operation the annular siphon N; this exhausts the air in M, and so sets the discharging-siphon to work. The siphon T empties the pit so far as

Fig. 4.



SECTION OF AUTOMATIC DISCHARGE-SIPHON.

its shorter leg extends, thereby regulating the amount of air left in the annular siphon N.

The advantages gained by the use of a scum-tank are: first, all road-grit and other such heavy particles of inorganic matter, which would tend to clog the first beds, are retained in the grit-chamber, whence they can be pumped out by a chain-pump provided for the purpose; second, the sewage is stored until there is a sufficient quantity to fill a bed; the filling is done rapidly in 55 minutes, thereby giving a longer period for aeration; third, owing to the width of the tank and to the fact that the inlet and outlet are placed at the extreme ends, the flow between these points is very slow, allowing precipitation to take place; and fourth, the inlet and outlet being by means of dipping-pipes,

which admit and draw off the sewage about 3 feet below the mean water-level, the surface is never disturbed, and thus a thick scum is allowed to form, under cover of which anaerobic action, *i.e.*, the liquefaction of the solid matter, takes place. These dipping-pipes have also the additional advantage of preventing solid matter from entering the beds; but perhaps the uniformity in the character of the scum-tank effluent is its chief recommendation.

Under the old system, owing to the small average flow all operations at the brewery had a direct effect upon the beds. These were so small that a sudden discharge of brewery refuse might have been in itself sufficient to fill a bed, in which case the sewage would have been very strong; while, on another occasion, when the brewery was discharging little, the sewage might have been purely of a domestic character. This variation in the character of the sewage was moreover emphasized by brewing operations being more marked at certain seasons of the year. In a Report upon the analyses of samples taken at the works in May, 1899, Dr. Harvey, F.I.C., public analyst for Canterbury, made the following remark as to this difficulty:—"I fully believe that the sudden arrivals of such a fluid as this brewery refuse upon the first filter-bed practically paralyses anything like bacterial action altogether, owing to its enormous strength in soluble organic matter, and it seems to me desirable that some attempt should be made to detain all crude sewage upon its arrival at the works by means of a storage-tank of sufficient capacity, in order that by mixture of weak and strong something like uniformity can be secured in the fluid before charging the filter-beds with the same."

It has been proved that bacterial action is altogether stopped if the sewage is strongly acid. Where beds are to be worked automatically it is necessary that the conditions shall remain constant, since there can be no variation in the time of contact allowed to meet the requirements of any variation in the character of the sewage, as can be done where the beds are worked by hand. The scum-tank has, however, many disadvantages which cannot be overlooked. In the first place, any system in which a large mass of putrefying matter is stored as a step towards purification cannot in any way be looked upon as perfect, being little better than a return to the old cesspool. The ideal system would be that in which the process of purification is begun as soon as the sewage enters the sewer. In the second place it would appear that where a scum-tank is used the bacteria must take longer to mature in the contact-beds, owing to the retention of all solid matter in the tank. This involves either

the production of an impure effluent during a longer period, whilst the bacteria in the beds are maturing, or the necessity for passing the sewage temporarily through an extra set of beds for some days. If this has to be done the scum-tank might as well be omitted and this extra set of beds permanently retained, as it has been proved that sewage can be purified solely by means of aerobic action in contact-beds; but if this system is employed an extra set of beds will be required. There is, in the case of the scum-tank, still the sludge difficulty, which has to be overcome. The matter is one that must be governed by local conditions; in an agricultural neighbourhood this may present no great difficulty, but, on the other hand, if the works are situated in a town the disposal of sludge may prove an expensive item. The clogging of the beds does not affect the case from the point of view of efficiency, as it has been proved that the effluent from a clogged bed is in every respect equal to that from one which has maintained its capacity. It is true that the first beds will require at some time to be emptied and refilled with clean material; this, however, will not be necessary until their capacity has been so reduced that they are unable to deal with the quantity of sewage to be treated, or until they have become so clogged that the aeration is insufficient to support aerobic bacteria, when anaerobic action would at once commence. It is equally true that the scum-tank will also require to be pumped out periodically. The question for the engineer to decide, after taking all the circumstances of the case into consideration, such as the fall in the ground on the site of the works and the cost of materials and labour in the locality, is, therefore, whether it will be cheaper to construct a scum-tank and to pump it out periodically, or to clean out the first beds as occasion may require. In the works under description, the manholes O and V (*Figs. 1*) have air-tight iron covers, while the manhole P, the three filling-chambers B_1 B_2 and B_3, and the three feed-pits C_1 C_2 and C_3 have each a wooden cover. The sewage is conveyed from the pits C_1 C_2 and C_3 by wooden covered-in carriers, which discharge below the surface of the beds. By these means no sewage is exposed freely to the air until it has passed through the scum-tank and the first beds, and the smell, inseparable from any sewerage-works, has been reduced to a minimum. This is contrary to the principle of aerating the sewage as much as possible, but was rendered necessary owing to the site of the works being within 100 yards of the main road.

The three first beds are each 52 feet 6 inches in length by 24 feet 3 inches in width, sloping from 6 feet to 4 feet in depth

across the width of the bed, giving a liquid capacity of about 8,000 gallons. Along the full length of the lower side runs a channel 12 inches in width, sloping from 1 inch in depth at the upper end to 6 inches at the lower end. This channel is covered with a cast-iron grating and forms the main drain for rows of 3-inch drain-pipes placed across the width of the bed, 2 feet 6 inches apart. The filling-material consists of a 6-inch layer of unbroken clinker, on which is laid 1-inch clinker to an average depth of 2 feet, the top being finished off with a 6-inch layer of 3-inch clinker, the surface-level of the bed being kept 6 inches below the coping. Two hours are allowed for contact from the time a bed is filled, it being then discharged by the automatic discharge-siphon already described, *Fig. 4.*

Each bed is also provided with a discharge-valve worked by hand, which draws off at a lower level than the discharge-siphon, so that the beds can be run absolutely dry if necessary.

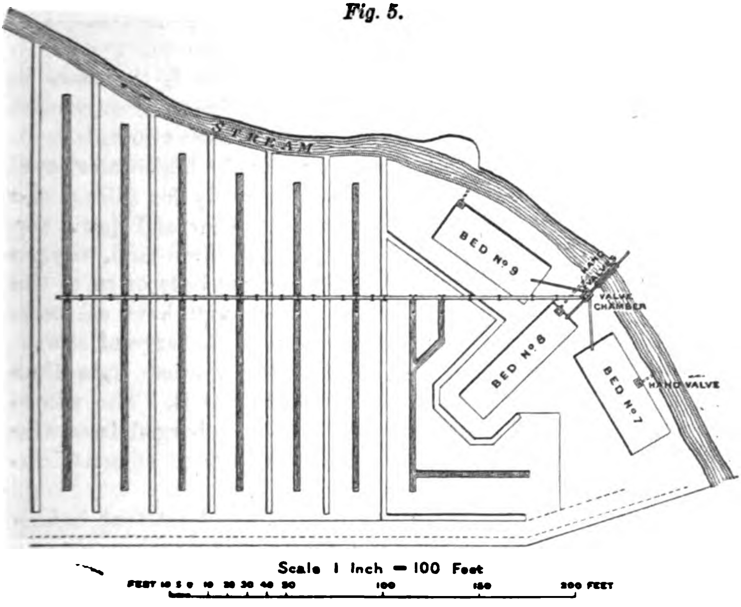
The effluent from the first beds passes on to three second-contact beds, each 30 feet by 31 feet 6 inches, by 3 feet 6 inches at the shallow end, sloping to 4 feet 6 inches at the deeper end. The first and second beds are intended to be worked in pairs, but any first bed is capable of being connected to any second bed. The under-drainage of these is the same as in the first beds, while the filling consists of 3 feet 6 inches depth of ½-inch material. They are automatically discharged after 2 hours' contact, and the effluent passes through a valve-chamber, from which it can either be turned on to third-contact beds or on to specially prepared irrigation-land.

The following was the method adopted in carrying out the work:—

The sewage was diverted at manhole O (*Figs. 1*) but was still being treated on the old beds. The 9-inch cast-iron main was laid between manholes O and P. Part of the latter was built, there being a temporary dam in the position of the disk-valve; and the overflow-sewer was laid to manhole R. This manhole was partly rebuilt, and the 9-inch cast-iron pipe was laid to the valve-chamber on the irrigation-land in place of the existing 6-inch pipe (*Fig. 5*), where four temporary contact-beds, 70 feet by 9 feet by 3 feet, and two beds, 35 feet by 9 feet by 3 feet, were dug out in the clay and were filled with the material from the old experimental beds as they were emptied. The sewage was then turned at manhole O into the new 9-inch sewer and passed down the overflow-drain into the new temporary beds, which were used to treat the whole of the sewage during the construction of the

works. All surplus material, in excess of that required for the formation of embankments, was removed on to the irrigation-land as it was excavated from the site of the new beds. Towards the completion of the work the temporary beds were emptied and the filling-material was mixed with the excavated spoil and placed in a layer, 18 inches in depth, over the surface of the irrigation-area. The land was then trenched all over for a depth of 12 inches below the original surface-level, this top 12 inches being thoroughly mixed with the new 18-inch layer, thus forming 2 feet 9 inches depth of good filtering material. Channels 2 feet in width by

Fig. 5.



PLAN OF IRRIGATION-LAND.

1 foot in depth were then formed at distances of 15 feet apart, running the full length of the land. Grips to carry off the effluent were placed mid-way between the channels; these grips discharged direct into the stream. A wooden carrier conducts the sewage from the valve-chamber to the channels, which are fed by side-shoots from the carrier, the supply to each being controlled by hand-valves. The liquid filters laterally, through 6 feet thickness of material, from the channels to the grips, which conduct the effluent to the stream. The temporary beds were enlarged, where convenient, by removing the earth between two adjacent

beds, and so converting two beds into one, and forming three permanent third-contact beds capable of taking the contents of a second-contact bed. All brick rubbish and broken concrete accumulated during the construction of the work was put into the bottoms of these third-contact beds in a layer, 6 inches in depth, and rows of agricultural drain-pipes were embedded in it 4 feet apart. These beds were then filled with the clinker-dust screened from the material brought to the site for the filling of the first- and second-contact beds. Small pits of 9-inch brickwork, with open cross-joints, were built in the beds round the outlets, which consist of 6-inch cast-iron disk-valves. These beds are controlled entirely by hand, and discharge direct into the Durlock stream. The storm water overflow-drain is divided from the main outfall-sewer by a weir in manhole P, the level of which is the same as the high-water level in the tank. By this simple arrangement no storm-water passes over the weir until at least two beds have been filled, and the liquid has again risen to the high-water level in the tank. If, by this time, no bed is ready for filling, the surplus water will then pass away over the weir and down the overflow-drain to the valve-chamber on the irrigation-land, whence it can either be passed through the third-contact beds, or on to the land. As the first foul flush of the sewers will have all been allowed to pass on to the beds, the subsequent discharge of storm-water mixed with sewage will be in such a diluted state that single contact has been found sufficient to treat it. The whole operation, from the time the sewage is first discharged from the scum-tank to the time it is discharged as a purified effluent into the stream, occupies 9 hours.

The brewery effluent undergoes a preliminary treatment before it arrives at the works. This consists of passing it through one of two filters each 18 feet 9 inches by 5 feet, by 5 feet 6 inches in depth at the shallow end, sloping to 6 feet in depth at the deeper end. The under-drainage consists of bricks laid upon edge, on which are placed slates. On these 1-inch coke is laid to an average depth of 1 foot 3 inches, the top being finished off with 6 inches of ½-inch coke, covered with a 3-inch layer of clinker, ¼-inch and smaller, but care was taken that there should be no dust. No purification is expected in these filters, which are required to act merely as a screen to intercept hop-seeds and yeast. Indeed, of two samples taken, one of the sewage as it entered a filter and another of the effluent, the latter was the first to show signs of decomposition. A 3-inch layer of sand was tried for the top filtering material, but owing to the gelatinous nature of the

yeast it formed a perfectly water-tight surface and had to be removed. Coke-breeze was then tried, but it proved impossible to clean the surface without removing a large quantity of the coke. The heaviness of the clinker and the fact that it does not bind have, however, overcome this difficulty, and the filters are now working well. These filters are worked alternately for three days each, during which time about 4 inches depth of solid matter is intercepted; this is carefully removed and placed on a dung-heap alongside, with which it is mixed and sold for manure. Owing to the fineness of the top covering, the body of the filter remains perfectly clean.

In conclusion, the Author desires to express his indebtedness to Messrs. Anson and Shenton for the assistance they have rendered him in preparing this Paper, and also to Mr. Easdale, of Messrs. Adams and Company, for his kind assistance in regard to the diagrams illustrating their apparatus.

The Paper is accompanied by five drawings, from which the Figures in the text have been prepared.

(*Student's Paper No. 504.*)[1]

"The Birkenhead Electric Tramways."

By Waude Thompson, Stud. Inst. C.E.

In 1860, George Francis Train, an American engineer, obtained the sanction of the Town Commissioners of Birkenhead for the construction of the first tramway, or, as it was then called, street railway, in Europe. The conditions imposed were very severe, for, besides bearing all the expense of the construction, Mr. Train had to maintain the roadway alongside the rails in repair, and to take up the line whenever required to do so. The work was pushed forward with great energy, and six weeks after its commencement the line, from Woodside Ferry to the Park, was opened for traffic. The type of permanent-way adopted was a flat rail with a ridge in the centre, the wheels being grooved to receive it; this, however, did not prove satisfactory, the cars frequently coming off the line, and two years later grooved rails with flanged wheels were devised by the Town Surveyor, and were adopted by Parliament as a standard type. The system was gradually developed and extended, new routes being opened as required to meet the increasing demands of traffic. In 1890 the lines came into the possession of the Corporation, and were leased by them to two private companies, and in 1896 the Corporation obtained powers to work these lines by electricity. The old method of horse-haulage, however, remained until in May, 1898, the Town Council adopted a comprehensive scheme of electric tramways prepared by the Borough Engineer and Borough Electrical Engineer, and powers were obtained from Parliament in the "Birkenhead Corporation Tramways and Improvement Bill, 1899," for the reconstruction of about 10 miles of existing single track, and for the construction of about 6 miles of new double track, and 3 miles of single track. The lease of one of the pr[illegible]panies having expired, and the interest of the other

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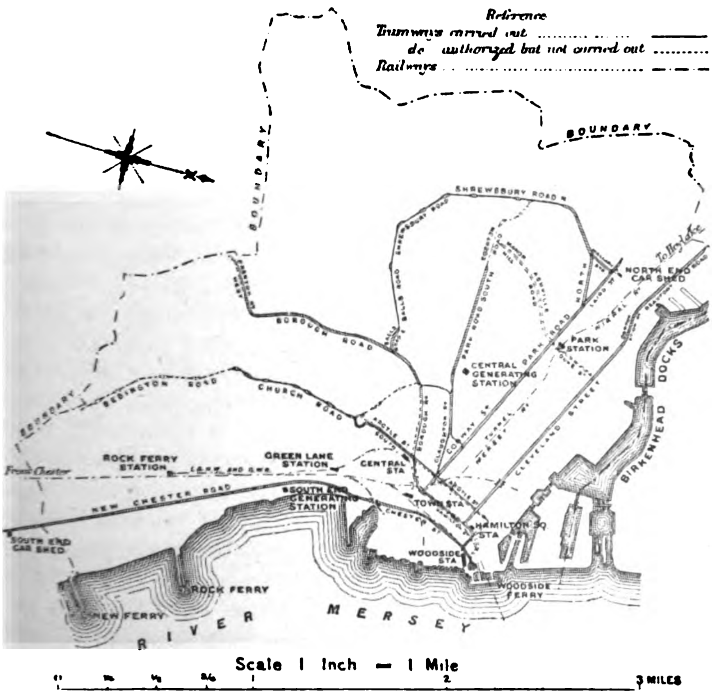
[1] [illegible]d discussed before a Meeting of the Birmingham Association [illegible] Institution on 12 February, 1903.

company having been bought out, work was commenced on the New Ferry Route early in 1900.

Although having a population of more than 110,000 inhabitants, Birkenhead exists to a great extent as a suburb of Liverpool, and, in consequence, the main lines of traffic converge on that point where means are provided for crossing the River Mersey, *Fig. 1.* The routes all meet at Woodside Ferry, which is owned and worked by the Birkenhead Corporation, and thence branch off

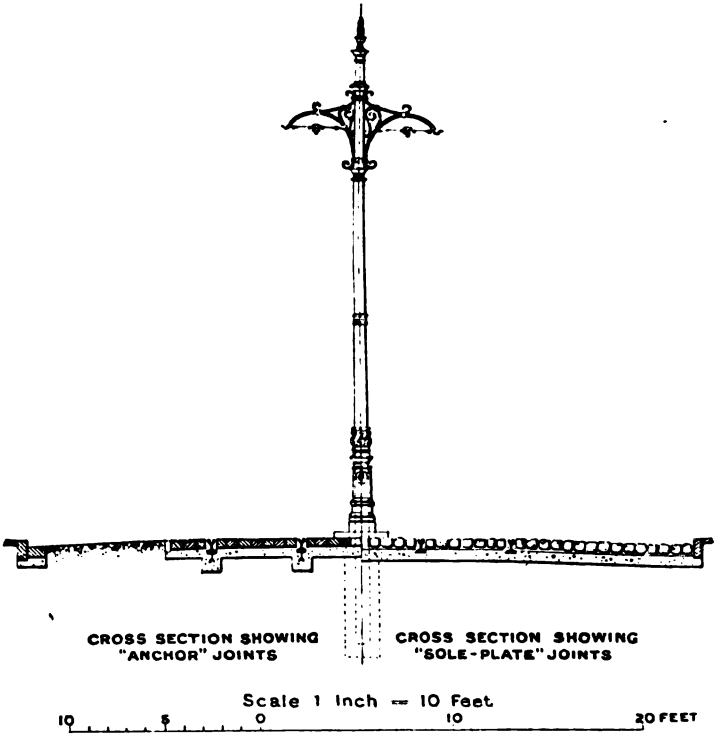
Fig. 1.



in various directions to the outlying portions of the Borough. They have been laid with the view of their being ultimately connected to form continuous or circular routes, giving the residents at the outskirts of the town a more frequent service of cars by having the choice of two routes. Powers were obtained for laying double track along all streets of sufficient width, and in the narrower streets single track was laid, in its proper position in relation to the ultimate width of the roadway after improvement. The Tramways Committee decided, with the view of

keeping down the initial capital cost, that at first only single tracks should be laid along most of the routes, but it was soon found that a frequent car-service could not be efficiently maintained under these conditions, even with passing-places at short distances apart, and in all except one short route the original plan has been adhered to. The whole scheme has been carried out, with the exception of about 1 mile of double track and $1\frac{1}{2}$ mile of single track, which it is not intended to lay down at present.

Fig. 2.



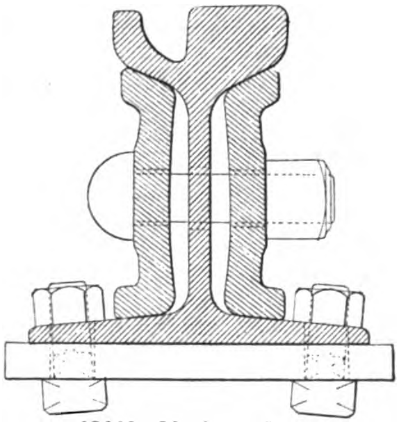
Permanent-way.—The track is constructed of steel girder-rails in 60-foot lengths, weighing 100 lbs. per yard, and is laid to the standard gauge of 4 feet $8\frac{1}{2}$ inches, with 6-foot centre-ways where the overhead trolley-wires are carried by centre-poles, *Fig.* 2, and 3-foot 6-inch centre-ways where they are carried by side-poles, the width of the centre-way being increased on all curved portions of the track to allow of the overhanging ends of the

cars clearing one another. The rails are 7 inches in depth and 7 inches in width of flange, with a 1-inch groove on straight track, and a 1¼-inch groove (the limit permitted by the Board of Trade) on curves. The tread is flat and 2 inches in width, and the guard is $\frac{9}{16}$ inch in thickness, and $\frac{1}{8}$ inch below the level of the tread, *Fig.* 3. The following conditions as to the chemical composition and quality of the steel were imposed:—

Carbon not to be less than . . .	0·50 per cent.
Silicon „ „ more „ . . .	0·06 „ „
Phosphorus not to be more than . .	0·08 „ „
Sulphur „ „ „ „ . .	0·06 „ „

and it was required to satisfy the following tests:—In a piece of rail 5 feet in length supported on bearings 3 feet 6 inches apart, the permanent set produced by a weight of ½ ton falling through 10 feet was not to exceed ¾ inch after the first blow, or 1½ inch after the second blow; and two additional blows, each with a weight of 1 ton falling from the same height, were to produce no sign of fracture in the rail. The joints between the rails are formed with steel fish-plates 2 feet in length, weighing 54 lbs. per pair, and fastened with six 1-inch bolts secured with lock-nuts, and on the tracks first constructed they were further strengthened by steel sole-plates, 2 feet by 8 inches by ¾ inch in thickness, weighing 38 lbs. each, and fastened to the rails by twelve 1-inch bolts and nuts, *Figs.* 4; but on the more recently constructed tracks "Anchor" joints have been adopted, a 2-foot length of inverted rail being used instead of the ordinary flat sole-plate. The gauge is maintained by wrought-iron tie-bars, 2 inches by ½ inch, slotted at one end and bolted at the other, fixed 10 feet apart.

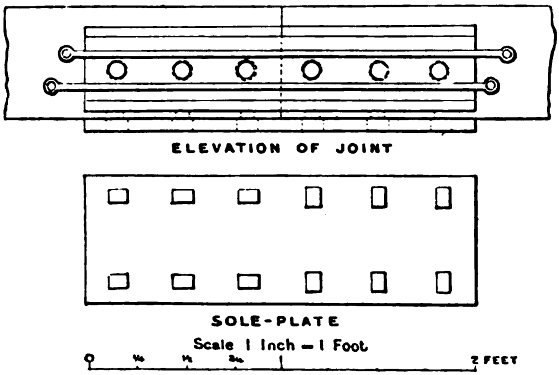
Fig. 3.



The first method adopted for laying the rails was, after the ground had been excavated to a depth of about 13 inches, to place them upon concrete blocks 12 inches square and 6 inches in depth,

fixed about 12 feet apart. When the joints had been bolted up, the tie-bars fixed, and the rails completed and set to finished levels, a bed of concrete, composed of five parts of broken stone, two parts of sand and one part of Portland cement, was packed and rammed under the rails and finished to the level of the underside of the paving. This method allows the work to proceed with much greater rapidity than that adopted later, there being only one period of setting for the concrete, but to ensure a solid bed the concrete has to be heavily punned or rammed to pack it tightly up to the rails, and this is liable to disturb their true alignment and levels. The handling also of a large mass of concrete over the rails to place it in position, is found at times to lead to a disturbance of the rails, causing delay for readjustment when it is

Figs. 4.



of greater importance to get the concrete into position. In the method adopted in some of the later portions of the work a bed of concrete was first laid, about 6 inches in thickness, left rough, and allowed to set for 3 days. The rails were then placed upon it in proper position and were linked together with fish-plates and a couple of bolts, after which the tie-bars were inserted, the joints completed, and the rails straightened where necessary. In order to insure a true gradient, at least three lengths of rail were bolted up before they were raised and packed to finished levels. The packing consisted of fine concrete, composed of three parts of granite chippings and grit, to one part of Portland cement. The end of the third length was lifted first and the rails were packed every 20 feet until the rail-surface had a true "bone" from end to end. This being done, the remaining portions were packed, care

being taken that the beating was not so severe as to form "humps" through the packing being too high, grout or liquid cement being also used as required. The concrete bed was then thoroughly cleaned and wetted, and brought up to its proper surface-level. Although this requires more time than the former method to allow the two layers of concrete to set, its advantages are that it enables the engineer to ensure that the underbed of concrete is sound, and it involves less likelihood of the rails being disturbed when set and fixed in proper position. Both these methods have advantages and disadvantages, and too much stress cannot be laid upon the necessity for careful supervision in laying the concrete foundations and in the strengthening of foundations under points and crossings. In order more effectively to bind the rails to the underbed and to prevent creeping, holding-down plates, 12 inches by 8 inches by $\frac{3}{4}$ inch, have been fixed on all gradients, below the concrete foundations, every 20 feet, and fastened to the bottom flange of the rail by two 1-inch bolts; and in the more recent tracks this system has been extended over the whole length, being found very successful in preventing the rails from springing. In addition to these plates, the track has been further strengthened at the ends and in the centre of curves, by inverted cross-rails bolted to the underside of the track. No special difficulty was experienced in handling the 60-foot rails—certainly none to justify the extra joints and bonding required by using shorter lengths.

In the first part of the work the points used were 7 feet 6 inches in length, with both grooves straight, but on the later works 12-foot points, with grooves curved as required to change the direction of the moving car as gradually as possible, were adopted in most cases. An inverted cross-rail, acting as a tie-bar, is laid across the track at each set of points, and is bolted to the heel of each point and to the adjoining rail, thus giving strength to one of the parts of the track subjected to great shock. To overcome the objectionable "clanging" noise when closing, the spring-points are fitted with the MacKnight silent-closing tramway-point controller, which consists of a cylinder filled with oil, containing a piston to which the rod, kept bearing against the tongue of the points by the spring, is fixed. The piston has a non-return valve and a small relieving-orifice. When the tongue is opened it compresses the spring and pushes the piston inwards, causing the valve to open and thus allow the oil to pass quickly to the front of the piston. The moment the wheel has passed, the spring expands and the valve closes, the oil having to return through the small relieving-orifice, which renders the tongue noiseless in closing.

These controllers have proved very useful in removing complaints, especially where points have been laid in closely-populated and narrow thoroughfares. All points are drained to the sewers.

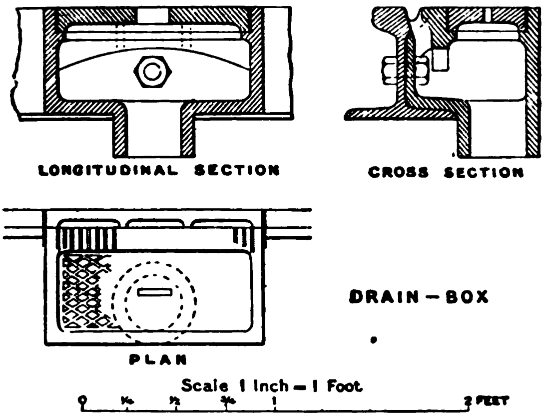
Cast-steel crossings, with angles of 1 in 5 and 1 in 6 have been chiefly used for cross-over roads, passing-places, etc., but at the car-sheds, where the wear is not so great, scarfed or built-up crossings were adopted. These were formed by placing an inverted rail across the through-rail and bolting it to the underside of the cut rail, further strengthened by angle fish-plates and bolts of different lengths fixed across the least angle from rail to rail.

Most of the curves are laid out with compound or parabolic curves, formed by an easy entrance-curve and connecting to one of smaller radius; the sharpest curve is of 40 feet radius to the inner or nearer rail, and to allow this to be attained the footpaths at certain junctions had to be altered. At the bottom of steep gradients, and on all curves of small radius, strips of hard steel, 5 inches by $\frac{3}{4}$ inch, have been bolted to the guard side of the rail, both to strengthen the guard and as an extra precaution against cars leaving the track. The paving being laid level with the top of these strips, no inconvenience is being experienced by vehicular traffic. The rails were usually bent on the site, except for standard cross-overs and special work for the junctions of busy streets, which were laid out at the depôts. For straightening any rails slightly crooked in transit from the rolling-mills, an ordinary crow was used, fitting the head of the rail only; but for curving the rails hydraulic crows or rail-benders were employed. These fit the entire section of the rail, thus ensuring bending of all parts simultaneously. The rails were cut when required by means of Whardown circular saws worked by two men, the average time occupied in cutting a rail being 30 minutes. For small works and extensions now being carried out, full-size templates, of railway-curves struck to various radii, are kept. Thus rails may be sent from the depôt, cut and curved, ready for fixing. For draining the rain-water from the track, cast-iron drain-boxes, $13\frac{1}{2}$ inches in length by 8 inches in width, bolted to the side of the rail, were employed. These boxes have inlets at the sides, level with the bottom of the groove of the rail, and outlets connected by 4-inch pipes to the sewers, *Figs. 5.*

The construction of the permanent-way was undertaken by the Borough Engineer's Department without the intervention of a contractor. The workmen employed were formed into one large gang of about 250 to 300 men, and several smaller gangs at various points, finishing off at the more difficult places on the routes, the

total number being 450 men. The following organization was adopted in the large gang: The excavators numbered about one hundred and twenty men, with, say, ten carters. The concretors were divided into two parties, each of about eighteen men, under a banker; the concrete having to be mixed twice dry and twice wet, eight men were required for mixing, four on each side of the stage, with one man pouring and another carrying water, and in addition to these were two men laying, two ramming, and about four wheeling, giving a total of thirty-six, or say, forty concretors; where the track was to be paved with wood an additional twelve or fifteen men, including two plasterers, were required for floating and bringing the concrete to a smooth surface. The platelaying gang numbered about twenty men, under two platelayers, one

Figs. 5.



superintending the crowing or bending, and the other the laying and bolting together of the rails. The paviors, including tar-boilers and labourers, were thirty-five in number. The excavators maintained a distance of three rail-lengths, or 60 yards, ahead of the concretors, who were in turn a sufficient distance in front of the platelayers to allow the concrete to set for 3 days before the rails were placed upon it.

The rails were bonded with two "Chicago crown" solid copper rail-bonds, each 0·166 square inch in sectional area and 29 inches in length, and having a surface-contact with the rail of 1·37 square inch, the track being cross-bonded with bonds of similar cross-section every 40 yards, and inter-cross-bonded, on double-track, every 80 yards. The bond-holes were carefully rimered to give a

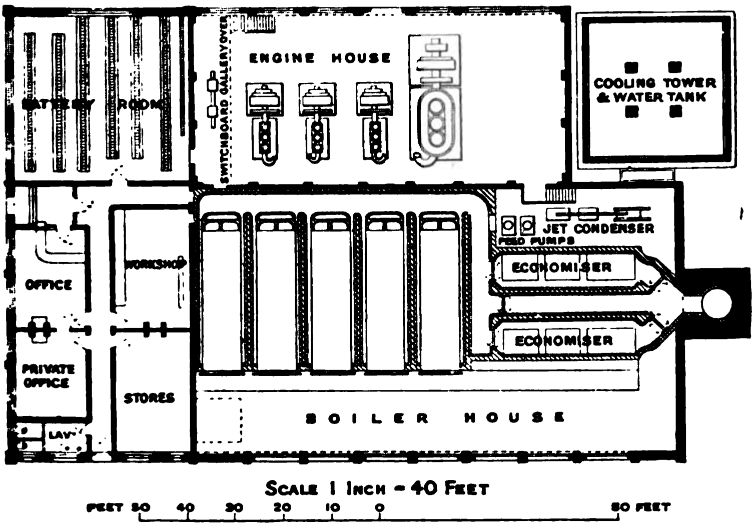
bright surface for contact with the copper bond. The tracks were paved partly with granite setts and partly with wood blocks, both of which were laid level between the rails, in order not to interfere with the life-guards on the cars. The granite setts, 6 inches in depth by $3\frac{1}{4}$ inches in width, were obtained from Penmaenmawr, Carnarvon, and Ireland. The wood-paving consists mainly of "American red gum" or satin-walnut and Baltic red deal blocks, 9 inches by 3 inches, by 5 inches in depth. The blocks were dipped in boiling tar and laid directly on to the concrete foundation, which was carefully finished smooth to the required levels. The paving was grouted or run, with boiling pitch and tar, with cement grout, or with 1-inch thickness of boiling pitch and tar finished off with cement-grout. The tops of the rails were coated with lime to prevent the grouting adhering to the metal. A space, $\frac{1}{2}$ inch in width, was left at each side of the rail and was filled with stiff cement-grout to reduce the disturbing effect on the wood blocks caused by the vibration. Where the sides of the roadway were not also paved, the wood blocks were laid for a width of 18 inches outside the track and the edges were left straight, granite setts being laid longitudinally between them and the macadam. The haunches, or spaces under the heads of the rails, were filled with lime-mortar, manufactured at the Corporation Refuse-Destructors, mixed with Portland cement in the proportion of 3 parts of mortar to 1 part of cement; and where this has been disturbed for any purpose, it has been found to have set hard and compact, and to adhere satisfactorily to the metal of the rails.

Overhead Electrical Equipment.—The trolley-wire used is 0·4 inch in diameter and consists of hard-drawn copper of 98 per cent. conductivity on the Matthiessen standard, having a minimum tensile strength of 25 tons per square inch, and is supported at an average height of 21 feet above the roadway by means of flexible suspensions, from cross-arms on poles placed in the centre of the roadway, or from bracket-arms varying in length between 10 feet 6 inches and 22 feet, on side-poles, in the narrower thoroughfares. The trolley-wire is doubly insulated, "Aetna" insulation being used throughout the system, and where these wires pass underneath telegraph- or telephone-wires, guard-wires, consisting of seven stranded galvanized-steel wires of No. 16 Standard wire-gauge, properly "earthed," are suspended above and outside of the trolley-wires in such a way as to intercept and "earth" a falling wire. The feeder-mains which conduct the current from the generating-stations to the overhead line consist partly of paper-insulated lead-covered cables, laid in earthenware conduits filled with

pitch-compound, and partly of cables insulated with vulcanized bitumen, laid in wooden troughing filled with bitumen. A three-core telephone- and test-wire cable is laid alongside the feeder-cables, providing telephonic communication with the generating-stations and car-sheds from the feeder section-boxes, which, for the purpose of connecting or disconnecting the feeder-mains and the trolley-wires, are placed at ½-mile intervals along the various routes.

Generating-Stations.—The electrical energy for operating the tramways is generated at two stations. The Main Central Station, in

Fig. 6.



PLAN OF CENTRAL STATION BUILDINGS.

Craven Street, supplies all the routes except the New Ferry Route, which is supplied by the South End Station in New Chester Road. The Central Station buildings cover an area of 1,535 square yards, and comprise a boiler-house, 139 feet by 95 feet, an engine-house 77 feet by 34 feet, and a battery-room 36 feet square, together with a workshop, store-rooms, and a suite of offices for the Borough Electrical Engineer, *Fig. 6.* The chimney-shaft, which adjoins the boiler-house, is 128 feet in height from the ground-level, and is 7 feet in internal diameter throughout. In the yard adjoining the main building is a reservoir 28 feet in length by 26 feet in width and 9 feet in depth, with a natural-draught chimney

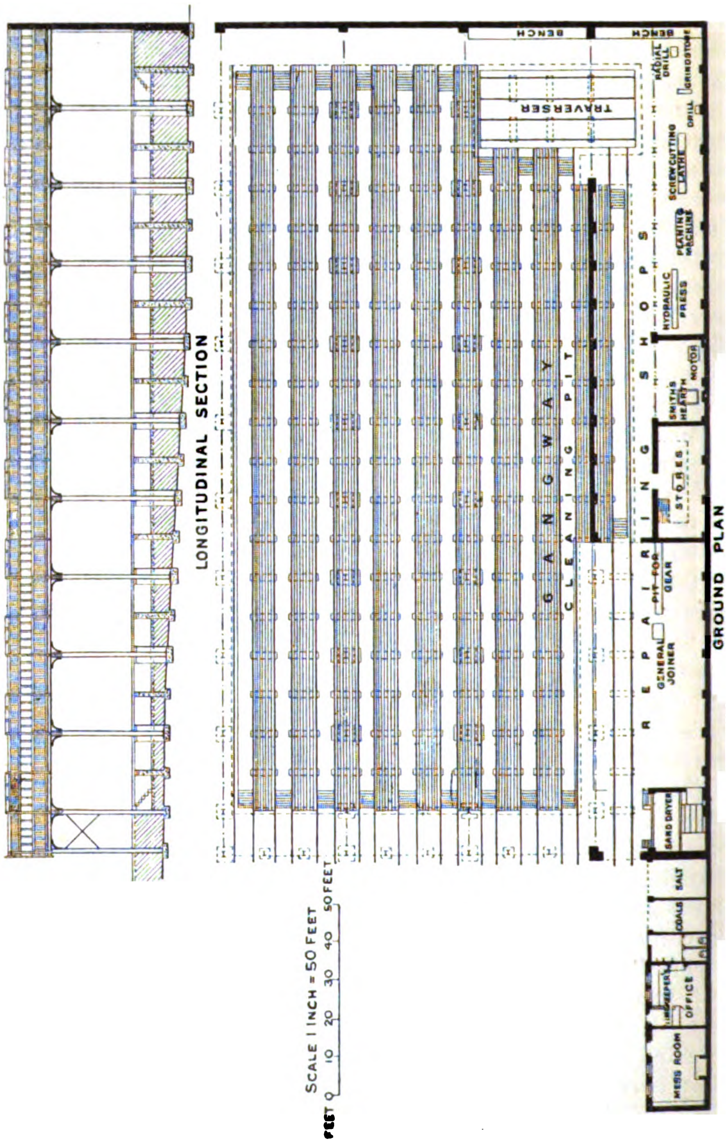
cooling-tower erected over it, for providing cold water for condensing purposes. Steam is supplied by five Lancashire boilers, 30 feet in length by 8 feet in diameter, each capable of evaporating 6,500 lbs. of water per hour at 160 lbs. pressure per square inch, fitted with McDougall motor-driven coking mechanical stokers, and fed by two steam-driven feed-pumps, each capable of delivering 2,000 gallons of water per hour against a pressure of 160 lbs. per square inch. Duplicate sets of Green fuel-economisers, each consisting of 320 tubes, are placed in the flue leading to the chimney. The steam-piping is made throughout of lap-welded steel tube with wrought-iron flanges, and is arranged on the "ring" system and provided with valves so that any section can be isolated in case of necessity; the exhaust-mains are of cast iron. The engines, four in number, are of the vertical compound condensing type, and are self-lubricating. Three of them are coupled to 225-kilowatt generators; the fourth, which has recently been erected, being coupled to a 500-kilowatt machine. The speed of the smaller sets is 350 revolutions per minute, the larger sets running at 270 revolutions per minute. The foregoing are the normal outputs, but each set is so constructed as to be capable of developing an emergency-load 15 per cent. in excess of the normal full-load. The generators are compound-wound, continuous-current multipolar machines, each provided with a series regulating-switch whereby the rate of compounding may be varied, or by short-circuiting the series-windings on the field-magnets the generators may be converted into simple shunt-wound machines, and so made available for use in parallel with the Corporation lighting-dynamos. An independent steam-driven "barometric counter-current" jet-condensing plant is provided, capable of dealing with 20,000 lbs. of exhaust-steam per hour. To cope with momentary increases of load, and generally to steady the load upon the engines, a storage-battery of 240 cells, capable of giving out 400 amperes for 1 hour, has been provided. Working in series with this battery is a compound-wound reversible booster so designed that when the power required by the line is less than the normal output of the engines running, the booster raises the pressure of the surplus energy and forces it into the storage-cells; and when the line calls for more power than the engines can supply, the booster raises the pressure of the battery-discharge up to that of the generators. By this means it is possible, even with the exceedingly variable demands of a tramway-circuit, to keep the load upon the engines within fairly narrow limits. The main switchboard, which is placed upon a gallery at one end of the

engine-house, is constructed throughout of steel and slate, and consists of four generator-panels, one battery-panel, one main panel, one Board of Trade panel, and six feeder-panels, furnished with magnetic blow-out circuit-breakers and the usual standard switches and measuring- and recording-instruments. Adjoining the main-board is a "throw-over" board, which connects the Craven Street plant by means of trunk-mains with the Corporation lighting- and power-plant in the Bentinck Street Works, and enables the Lighting Department to be supplied with electrical energy from the Craven Street plant, or *vice versa*, in case of necessity. A 12-ton overhead travelling-crane has been erected in the engine-house. The workshop is fitted with motor-driven machine-tools, etc., to enable the repairs necessary to the plant to be effected on the premises. The South End Station is a combined lighting and traction station, and contains plant similar to the foregoing in design, but of smaller units, the total capacity for both lighting and traction being only 450 kilowatts.

Car-sheds.—The principal car-shed and depôt is situated at the north end of the town, in Laird Street, and has accommodation for sixty cars, *Figs.* 7. The ground-level of the site was much below the surface of Laird Street, necessitating a considerable amount of filling to bring the floor of the shed approximately to the level of the street. Advantage has been taken of this circumstance by filling the interior to a depth of 7 feet in the shed proper and only 4 feet 6 inches in the repairing-pits, below the rails. The rails are supported on concrete walls, 18 inches in thickness, placed 10 feet apart, centre to centre, across the spaces, 6 feet in width, between the tracks, thus leaving a clear area throughout the shed under the rails, providing ample storage-room as well as greater convenience when cleaning or repairing the underside of the cars. The repairing-pits have been fitted with rails upon which moves a hydraulic lift-pump for changing wheels, axles, motors, etc. The spaces between the tracks have been filled in at rail-level with wooden flooring supported by the lower flanges of the rails. An electric traverser is placed at the end of the building to move cars into the repairing- and fitting-shops, which are equipped with a hydraulic wheel-press, a surface and screw-cutting lathe, radial drills, shaping-machine, cold saw, grind-stone, etc. These, together with a Root blower in the smithy, and a wood-working machine in the joiners' shop, are driven by a 15-HP. electric motor. Two overhead electric cranes run the full length of the shops. A sand-drying apparatus is provided near the entrance, consisting of

a small furnace connected to three triangular cast-iron flues placed side by side, $\frac{5}{8}$ inch apart and supported at the ends on brick walls

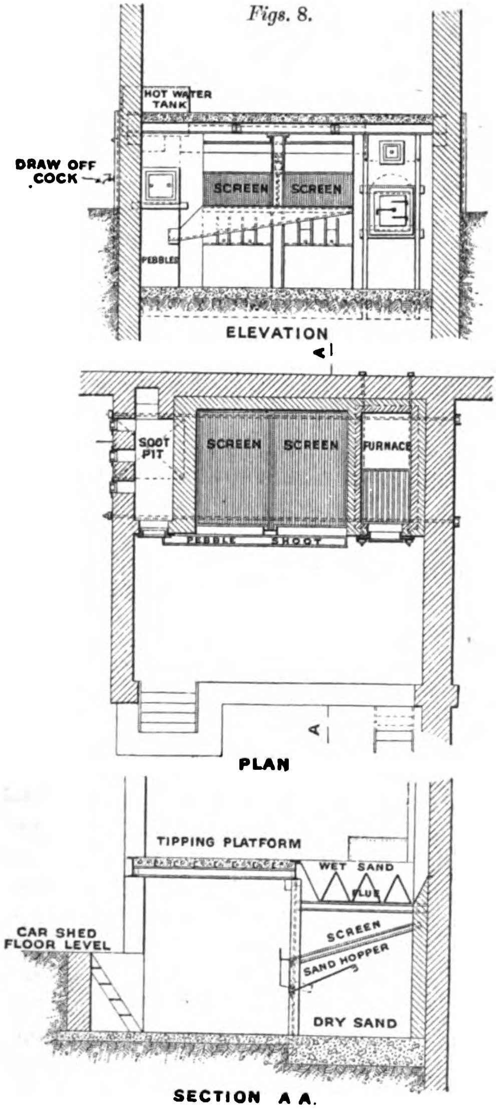
Figs. 7.



which are carried above the flues to form a container for the wet sand, which, as it dries, runs through the narrow spaces between

the flues on to sloping screens placed underneath, *Figs. 8.* The pebbles are caught and run down a shoot which carries them to a receptacle placed under the soot-pit, the sand passing through the screens into bins, in the fronts of which are small doors, through which the bags carried on the cars may be filled. The bins are so arranged that when they are full the sand falls into a storage-area below. The drier is sunk below the floor-level of the shed, so that the wet sand may be removed directly from the carts on to the storing platform. In addition to the accommodation already mentioned, the shed contains general stores, paint-shop, etc., and attached to the main building are the timekeeper's office, mess-rooms for men on night- and day-shifts, fitted with cooking-ranges food-lockers, etc., and stores for salt and coal. The shed has been designed for further extension for thirty-six cars,

Figs. 8.



SAND-DRYING APPARATUS.

in addition to the sixty cars now provided for. Offices for the Tramways Manager and Staff are being erected fronting Laird Street, adjoining the shed.

The New Ferry car-shed is used for the cars running on the New Ferry route only, its main interest being in the adaptation of an irregularly-shaped building, originally used for horse-cars, to receive modern electric tramway-cars. The depôt has been extended and altered, the entrance widened, the roof raised, and the necessary overhead equipment and cleaning-pits provided. The old stables have been converted into workshops, mess-rooms, sand-drier and stores. The shed now provides accommodation for fourteen cars.

Cars.—The cars are of three types, viz.:—single-deck bogie-cars, four-wheel double-deck cars, and double-deck bogie-cars. The single-deck cars, the use of which is necessitated by a low railway-bridge on one of the routes, with only 14 feet 6 inches available head-room, are 31 feet 6 inches in length, mounted on two maximum-traction bogie-trucks of the "Peckham" type, and equipped with two 25-HP. motors and controllers, supplied by the British Thomson-Houston Company. As originally supplied, each car consisted of three compartments, viz., a smoking-compartment at each end and a larger compartment in the centre, but as the partitions and doors which these compartments necessitated were found to be a nuisance, and as the smoke from the end compartments was found in actual working to fill the centre compartment, the partitions have been removed, thus providing one large saloon with a seating-capacity for thirty passengers and three passengers outside on the rear platform.

The four-wheel double-deck cars are 27 feet 7 inches in length, providing seating-accommodation for fifty-five passengers, and are carried on Peckham cantilever extension-trucks having a wheel-base of 6 feet, and motors and controllers similar to those of the single-deck cars. The cars are fitted with the "Birkenhead" staircase, which was designed at the car-works of Messrs. G. F. Milnes and Company, Birkenhead. This staircase is so arranged that inside and outside passengers can leave the car at the same time, and the outside passengers still have all the advantages of what is known as the "reverse" staircase, with none of its disadvantages. The greatest disadvantage of the "reverse" staircase is that a driver cannot see what is happening on the left-hand side of the car, and many accidents have resulted in consequence. Twin-doors are provided at each end of the car, which open simultaneously, being suspended on rollers at the top,

and connected by suitable mechanism, so that motion imparted to one door is transmitted to the other, the two doors thus working together and allowing a wide entrance to the car.

The type of car most recently adopted is a bogie-car, 34 feet 6 inches in length, providing seating-accommodation for seventy-five passengers, and mounted on McGuire bogie-trucks, fitted with four 20-HP. motors per car, which, along with the controllers and electrical equipment, have been supplied by Messrs. Witting Brothers, of London. The advantage of a bogie-car of this description is that, having all eight wheels of equal size, and a motor on each axle, there is no slipping, such as is experienced with the maximum-traction trucks, which have pony-wheels carrying practically no weight, and which are found in practice not to work well on steep gradients. It is also more easily controlled than a car fitted with a type of maximum-traction truck. These large cars have been fitted with the "Leather" ventilator, the principal feature of which are the baffle-plates fixed outside the car on a level with small ventilating-windows, which, when the car is running, cause a rush of air into the car at the front and a suction of air from the car at the back of each plate, thus causing a constant change of air to take place in the car.

The question of life-guards, which is a very important one on all tramway undertakings, received early consideration, and after several experiments the Tidswell life-guard was adopted in place of the rigid Peckham tray-guard which was supplied with the cars. This guard consists of two parts, viz., a gate or fender which hangs vertically across the front of the car, 4 inches from the ground, and so placed that nothing exceeding that size can pass under the car without pressing the gate backwards and in so doing liberating the trigger, which instantaneously drops the second part of the guard, a lattice-frame supported horizontally under the car about 2 feet 6 inches from the gate or fender, and 4 inches from the ground when not in action. The front of this frame drops on the ground and picks up anything which may have passed under the fender or tripper. Its sensitiveness has been shown by the fact that it has picked up fowls, cats, dogs, children, grown-up people and even men and bicycles, and in Birkenhead alone has saved eleven lives since the opening of the tramways about two years ago.

Various forms of "dry" seats were tried for several months, with the result that the Brawn "dry" seat has been fitted upon forty cars. This seat is composed of thin bevelled-edge laths bolted

together with transverse bolts, the laths being separated by wooden buttons or washers so as to allow the water to pass through. The laths are so bevelled as to leave practically no surface upon which rain can rest, thus securing a dry seat immediately after a shower. They can also be easily fixed to the framework of an ordinary seat.

The cars are fitted with three types of brakes, viz.: (*a*) the ordinary mechanical brake which applies blocks to the wheels and which is effective up to the point at which the wheels skid; (*b*) the electric rheostat brake, by which the motors are converted into generators and thus tend to retard the forward motion of the car; and (*c*) slipper-brakes, applied by a wheel on each platform, connected to a long screw pulling down a shaft fixed underneath the centre of the car, which thrusts down wooden poplar blocks on to the tramway-rails, thus taking the weight of the car. The use of the slipper-brake, with either the hand-brake or the electric brake, in a proper manner, renders it impossible for a car to get beyond control under practically any working conditions.

A snow-plough and a salt-sprinkler are used in winter time when required; and a water-tank has been constructed at the depôt, which is used for the purpose of cleansing the rails when necessary.

One of the most difficult pieces of work in the scheme was the construction of a new road across the side of Holt Hill, at Tranmere, which was rendered necessary by the gradients of the existing streets being about 1 in 7. The road is supported by curved retaining-walls and embankments, and the necessary distance to reduce the gradient has been obtained by a system of curves, the sharpest of which has a radius of 40 feet. The road is 350 yards in length, with a gradient of 1 in 13·5.

The terminus at Woodside Ferry is also of interest. It consists of a siding of six parallel tracks approached by double lines with cross-over roads, etc., so that a car may enter any of the six tracks from the "down" line and leave by the "up" line. The overhead equipment for this terminus is carried on poles having large double brackets, each bracket carrying three trolley-wires.

During the doubling of some of the routes, a temporary track was necessary. The track adopted was composed of steel rails $5\frac{3}{4}$ inches in width and $1\frac{1}{4}$ inch in depth, with a 1-inch groove in the centre, the outer edges being bevelled off to allow the ordinary vehicular traffic to cross it. The rails were in 24-foot lengths, weighing 54 lbs. per yard, and were simply laid on the surface of

the roadway, being held together by flat tie-bars, 3 inches by $\frac{3}{8}$ inch, every 8 feet, and 6-inch by $\frac{3}{8}$-inch bars at the joints. The ends of these bars were turned up and bent over the outer edge of the rail, clips being bolted to them at the inner side.

Cost, Expenditure, and Receipts of First Year's Working.—The tramways now in operation consist of 3 miles 4 furlongs 1·4 chain of single track, and 10 miles 2·2 chains of double track, making a total of 23 miles 4 furlongs 3 chains when reduced to single track.

The following is an account of the Expenditure on the Scheme up to December, 1903:—

	£	s.	d.
Main Central generating-station, buildings . . .	11,552	0	0
" " " " equipment . .	27,388	0	0
South End generating-station, buildings . . .	5,092	0	0
" " " " equipment . . .	9,588	0	0
Tracks [1]	151,854	0	0
Electric line work	32,580	0	0
North End Car Shed	20,018	0	0
" " Equipment	2,307	0	0
South End Car-Shed alterations and equipment	3,173	0	0
Offices for Manager and Staff	3,221	0	0
Cars (13 single-deck bogie-cars; 31 double-deck four-wheel cars; 15 double-deck bogie-cars) including spare parts, etc.	42,760	0	0
Legal and general charges	1,973	0	0
Cash office at Woodside Ferry and minor Expenditure	438	0	0
Total	£311,944	0	0

The cost of making the New Road at Tranmere was	£14,677	14	6

	£	s.	d.
The total income from March, 1901, to March, 1902 (the first complete year's working), was . . .	31,593	11	10
The expenditure was	28,079	7	5
Leaving a profit on the year's working of . . .	£3,514	4	5

The total quantity of electricity used during the year was 982,737 Board of Trade units, the car-mileage being 718,726 miles, or 1·36 Board of Trade unit per car-mile, including lighting of depôts and power for repair-shops. The cost per unit of electricity

[1] The work of construction was carried on regardless of weather, entailin^r expense for protection against frost, illumination for night-work, over-time, et

(exclusive of sinking-fund and interest) was 1·05*d.* The income was 10·54*d.* per car-mile and the expenses were—

	Pence.
Working expenses per car-mile	6·36
Interest, sinking fund, etc.	3·01
Total expense per car-mile	9·37

leaving a net profit per car-mile of 1·17*d.*

The Author desires to express his indebtedness to Mr. Charles Brownridge, Assoc. M. Inst. C.E., Borough Engineer, and Mr. William Bates, Assoc. M. Inst. C.E., Borough Electrical Engineer, the Engineers for the scheme, and Mr. A. R. Fearnley, Tramways Manager, for much of the information contained in this Paper.

The Paper is accompanied by four tracings, from which the Figures in the text have been prepared.

OBITUARY.

Sir GEORGE GABRIEL STOKES, Bart., D.C.L. (*Oxon.*), LL.D., D.Sc. (*Cantab.*), died at his residence, Lensfield Cottage, Cambridge, on the 1st February, 1903. He was born on the 13th August, 1819, at Skreen, in the county of Sligo, of which parish his father was Rector. At the age of 13 he was sent to Dublin, where he was educated at the school of the Rev. R. H. Wehl, D.D. In 1835 he was removed to Bristol College, of which Dr. Jerrard was principal. In 1837 he entered Pembroke College, Cambridge, of which he was the Master when he died; graduated in 1841 (a year before Cayley) as Senior Wrangler and First Smith's Prizeman; became a Fellow of his College in the same year; and in 1849 was elected Lucasian Professor of Mathematics in succession to Joshua King, Babbage, and Airy; and to Newton also in the same chair.

He was elected a Fellow of the Royal Society in 1851, and in the following year was awarded the Rumford medal in recognition of investigations on the refrangibility of light, published in the Philosophical Transactions for 1852. He was appointed one of the Secretaries of the Royal Society in 1854, and after numerous contributions to the Transactions of that and other learned societies, he became President of the Royal Society in 1885, a post which he held until 1890.

In 1889 he was created a baronet in recognition of his service to science, which was fully appreciated abroad as well as at home, and among numerous other distinctions he received the Prussian order *Pour le Mérite.*

He received honorary degrees from Cambridge, as well as from Oxford, Edinburgh, Dublin, Glasgow and Aberdeen. Sir George Stokes was President of the British Association at the Exeter meeting in 1869, and in the following year he was appointed to serve on the Cambridge University Commission; and later, he, like Newton, was a representative of the University in Parliament.

The celebration of the Jubilee of Professor Stokes was carried out at Cambridge in 1899 with great success, and representative men of science from all parts of the world were present in his honour. In responding to his health, Stokes apologised humorously for the small amount of work he had accomplished in a long lifetime; but then he added, if he had worked harder

he might not have been present at that his jubilee ceremony. Like Newton, again, Stokes was seized too early by the authorities for his administrative abilities, and must have left unfinished much of his best intellectual work.

After his jubilee Stokes felt it incumbent to attend the British Association meeting at Dover in 1899, and the memorable occasion of interchange of international courtesies with the French Association at Boulogne.

The connection of Sir George Stokes with engineering may be said to date from about 1843, when he acted as Secretary to a Parliamentary Commission on the strength of railway bridges, appointed after the fall of the Chester bridge. Trace of his work as Secretary of that Commission may be found in a mathematical Paper in the Transactions of the Cambridge Philosophical Society, vol. viii., entitled "A differential equation occurring in the theory of the bending of a beam under a moving load." This Paper was included with his collected Mathematical and Physical Papers published at Cambridge in 1880.

Sir George Stokes was elected an Honorary Member of the Institution of Civil Engineers on the 1st March, 1892.

An important appreciation of his work, with portrait, by Professor P. G. Tait, was published in *Nature*, 15th July, 1875; in that journal of the 12th February, 1903, Lord Kelvin gave an exhaustive summary of the scientific work of Sir George Stokes, showing the importance of its bearing on recent developments; and Lord Rayleigh has delivered recently at the Royal Institution a most valuable series of lectures on his life and work.—SEC. INST. C.E.

Sir FREDERICK JOSEPH BRAMWELL, Bart., D.C.L. (*Oxon.* and *Durham*), LL.D. (*Cantab.*), F.R.S., Past-President of The Institution of Civil Engineers,[1] died at his residence, 1A Hyde Park Gate, on the 30th November, 1903, in his eighty-sixth year, after a few days' illness from cerebral hæmorrhage.

Frederick Joseph Bramwell was the third son of a banker, Mr. George Bramwell, a partner in the firm of Dorrien and Co., of Finch Lane, London. He was born in the year 1818, the year of the foundation of the Institution, a fact in which he took delight. At the age of sixteen he was apprenticed to John Hague, a mechanical engineer, whose works, situated in Cable Street, Wellclose Square, were bought by the Blackwall Rope Railway,

[1] This notice is based on that which appeared in *Engineering* of the 4th December, 1903.

which originally terminated at the Minories and was afterwards continued to Fenchurch Street.

In those days specialization was not a feature in engineering industry, and Hague's practice covered an unusually wide field. Amongst other matters in which the young engineer was engaged was the vacuum system for distributing power; and it will be remembered that Sir Frederick Bramwell read a most interesting Paper at the Plymouth meeting of the Institution of Mechanical Engineers, held in 1899, in which he described the South Devon Atmospheric Railway. He was so impressed with the prospects of the system that, in the period between 1846 and 1850, in conjunction with his former fellow-apprentice, the late Samuel Collett Homersham, he worked out a proposal for a subterranean atmospheric railway between Hyde Park Corner and the Bank. There was also a proposal for a short length, as an example of the system, to run from the then existing Hungerford Market, the site of the present Charing Cross Station, over the suspension bridge, at that time standing, to Waterloo Station.

When he was out of his time, young Bramwell became the manager of Hague's works, and under his supervision a locomotive of the then considerable weight of 10 tons was built for the Stockton and Darlington Railway. This was in 1843, and the engine was taken north as deck cargo by the paddle-boat Emerald Isle, at that time the only steamer trading between London and Middlesbrough. Just 50 years later Sir Frederick, in speaking of the incident, said that "having driven the engine between Stockton and Darlington, and having received my money, I returned to London by coach." Shortly after this he became connected with the Fairfield Railway Carriage Works, Bow, which were under the management of William Bridges Adams. There he devised a means of making tires without welding, but experienced the disappointment, common to so many young inventors, of finding that someone had been before him. A similar fate attended the birth of another of his projects—that of constructing an endless band-saw; but in spite of anticipation in the previous century, he persevered with the idea, and designed a multiple arrangement of four band-saws for breaking down timber.

Sir Frederick Bramwell's early connection with what has grown to be the great motor-car movement of the present day has often been described, notably in his interesting Paper read in Section G of the Oxford meeting, in 1894, of the British Association. As an apprentice, he won the favour of Hancock, one of the earliest and most successful of the "steam on common roads" engineers.

Summers, another pioneer in this field, was a relation of Hague, and Sir Frederick not long before his death told how his first job as an apprentice was to hold the chisel whilst a road locomotive boiler was being cut up for scrap.

To follow Sir Frederick Bramwell's career through its earlier episodes would be largely to give a history of engineering progress of the day. To the present generation he was known as a "consultant," and it was in this field that he made his great reputation. Of the many societies to which he belonged, this Institution claimed him as essentially its own, although, as a mechanical engineer, he was strongly attached to the sister Institution at Storey's Gate, and up to the last few months of his life he was a frequent attendant at its Council meetings. In 1854 Sir Frederick Bramwell was elected a Member of the Institution of Mechanical Engineers. In 1874 he was elected President; and older members will remember the interesting and instructive address he delivered at the Cardiff meeting of that Institution. It was in the writing of an address such as this that he was particularly happy; the subject which he most loved was mechanical engineering—and from the rich storehouse of his memory he brought forth facts which he arranged with the skill of one who fully appreciated their significance in the march of engineering progress. In that address he said he could not indicate what would be the grand inventions of the subsequent half-century; but some years later—at the York meeting of the British Association in 1881, in the discussion on a Paper read by Mr. J. Emerson Dowson, on the subject of using cheap gas for gas-motors, he did venture on a prediction which seems not unlikely to be fulfilled, in spirit if not in letter. At that time the gas-engine had not been introduced to anything like its present extent; and the oil-motor, as it is now seen, was practically unknown. Nevertheless, he prophesied that in 1931, when the British Association might be holding its centenary meeting in York, the steam-engine would only be seen as an interesting relic of a past age, having by then been superseded by the internal-combustion engine. To an engineer, realising what an imperfect instrument the evaporation of water affords for the generation of power, the forecast may not seem now a very bold one, with gas-engines up to 1000 HP. no longer a thing to wonder at, and with boats driven by oil-engines at a speed not to be approached by steam vessels of the same size. In all cases, however, the fulfilment of a prediction such as this takes from its wonderment, and to Frederick Bramwell must be given all the credit of priority in his forecast.

He was elected a Fellow of the Royal Society in 1873, and occupied an important position in that learned body, serving for a time on its Council. He was also a most prominent Member of the Royal Institution, becoming Honorary Secretary in 1885, and from that time, until his retirement from the office in June 1900, taking a most active part in the affairs of the Institution. He was a constant attendant at the annual meetings of the British Association, being President of Section G—then known as the "Mechanical Science Section"—in 1872, when he delivered another most interesting address, in which he again described, with a lucidity characteristic of him, certain mechanical inventions, the influence of which he traced. In 1888 he was elected to the presidential chair of the Association, the meeting that year being held in Bath. On that occasion he delivered an address, his theme being "Next to Nothing," by which he worthily upheld the reputation of the branch of applied science which he represented. He joined the Society of Arts in 1874, and was for a number of years a Member of Council and a Vice-President, and filled also the posts of Treasurer and Chairman of the Council; occupying for a short time the post of President before the present Prince of Wales accepted that office. His communications to the proceedings of these and other bodies were numerous, but it is unnecessary to select any for special mention here; and still more numerous were his oral contributions to the discussions, in which he took a prominent and pertinent part. In 1883 Sir Frederick Bramwell delivered before this Institution one of the special series of lectures on the Applications of Electricity, his subject being Telephones. During his period of office as President, he and Lady Bramwell gave a memorable Conversazione, in June, 1885, at the International Inventions Exhibition, of the Executive Council of which he was Chairman.

In this sketch of Sir Frederick Bramwell's career mention has been made chiefly of his consulting practice and of his connection with scientific societies; but he was also engineer to many undertakings of varied kinds during later years, being associated in such work with his partner, Mr. H. Graham Harris. Although Sir Frederick was born before the era of technical education, he had a keen and just appreciation of the value of scientific attainments in the equipment of the engineer. He took a leading part in the movement which led to the great City Companies and the Corporation founding the technical schools which have become associated in the City and Guilds Institute. His work on the Ordnance Committee, to which he was appointed in 1881, and

his labours in connection with the Inventions Exhibition are well known, the success of that most successful Exhibition being chiefly due to his energy and genial tact. He received the honour of knighthood in 1881, whilst in 1889 he was created a baronet. The title, however, expires with his death, as he leaves no son. He was a D.C.L. of Oxford and Durham and LL.D. of Cambridge and McGill University, Montreal. He was married in 1847, and is survived by Lady Bramwell and two daughters, of whom one is the wife of Sir Victor Horsley and the other of Sir Henry Bliss.

To the last he was an active worker, with mind as vigorous and heart as warm as ever; even when his bodily powers began to feel the increasing weight of advancing years, his zest for engineering and all its associated interests seemed to be but enhanced thereby. Seventy years of active work out of a life of eighty-five constitute a conspicuous example of energy combined with longevity. His experience during so long and active a life naturally embraced an extensive variety of subjects and of places, of which his reminiscences were continually cropping up, enlivened by a never-failing touch of humour. Sir Frederick maintained, even to the day of his death, a foremost position amongst engineers. His strong mechanical instinct, retentive memory, ready wit, and, not by any means least, his picturesque and venerable appearance, enabled him to hold his own, in his particular field, among those of a younger generation whose advantages for acquiring knowledge had been infinitely greater. It was as a debater and expert witness that he especially made his mark. The forensic ability which characterized his distinguished brother, the late Lord Bramwell, seemed to be his by right of inheritance. Never at a loss, he could baffle the most wily or most resolute cross-examiner, and probably no lawyer ever extracted from him anything he did not want to say. Many are the tales told, both in the Inns and at Great George Street, of the wordy duels between Sir Frederick and his would-be persecutors; but whether the weapon used against him was the rapier or the bludgeon, he had a guard that seldom failed.

In the more peaceful atmosphere of discussion at the various scientific and technical societies, of which he was a member, his genial nature was more apparent; and to the younger members of these institutions he was always kind and charming, so long as they were not presumptuous or affected.

His connection with the Institution was well summed up in the resolution which, on the motion of the President, Sir William

White, was adopted unanimously at the Council Meeting on the 1st December, 1903, the day after his death.

"This Council have received with great regret the intimation of the death of their esteemed colleague Sir Frederick Bramwell, Bart., F.R.S., etc., etc., Past-President.

"The Council desire to convey to Lady Bramwell and her daughters the expression of their sincere sympathy in this bereavement, and their high appreciation of the great services which Sir Frederick Bramwell has rendered to The Institution of Civil Engineers and to engineering during his long and distinguished professional career.

"He was elected an Associate in 1856, and transferred to full Membership in 1862. Since 1867 he has served continuously on the Council, having been elected Vice-President in 1880, and President in December, 1884, occupying the Chair until May, 1886.

"The Institution owes much to his unwearied service, his wise counsel, unfailing generosity and active work in connection with the initiation and foundation of the Benevolent Fund.

"His loss will be severely felt both in the business of the Council and at the Ordinary Meetings. No member of the Institution was a more faithful attendant at its Meetings or made more valuable contributions to the Proceedings. With wide and varied experience were united gifts of expression and humour, as well as a ready appreciation of what was most valuable and promising in novel proposals.

"His colleagues desire to record their sense of his distinguished personal qualities, and will ever hold them in remembrance."

In moving the approval and endorsement of this Resolution by the Ordinary Meeting in the evening (which was subsequently adjourned as a mark of respect to the memory of Sir Frederick Bramwell) the President said that he would like to add one or two words of personal acknowledgment, and personally to express his sense of the loss the Institution had sustained by the death of their dear friend, whose long connection with the Institution and whose faithful service could not be exaggerated. Sir Frederick Bramwell was an example to them of loyalty and devotion to the work of their great association. It was nothing short of life-long devotion; he never tired. They all remembered how only four weeks ago he sat among them, and in words which moved him deeply proposed a vote of thanks for the address which he (Sir William White) as President had just read. His great generosity, his interest in everything done for the welfare of those connected with the Institution, his continued work for the Benevolent Fund, were all

signs of the great interest Sir Frederick took in the Institution. Then, too, he was marvellously sympathetic, especially to young men, and he never seemed to grow old in regard to his interest for young men. He was ever interested in what was new, and ever encouraging those who were trying, with never one unkind word, although he said many clever things. He had the art of terse expression, and he could take an idea, clothe it in a new form, and give it back improved to the originator. Sir Frederick loved work; and he remembered his saying, "I shall never retire; life to me is work, and I will work to the end." And so he did. He never gave up, and last Sunday night he dictated to his daughter a message which said he had looked forward to the opportunity of supporting his dear friend Sir William White in the chair as President during the session, and it was a source of bitter regret that that could never take place. He was true till death and never forgot the Institution or his friends, and the resolution he moved expressed their recognition of the gratitude for such a life and for such a death.

Sir John Wolfe Barry, in seconding the motion, remarked that Sir Frederick Bramwell was essentially the father of the Institution, and it was as near to his heart as anything could be in this world. He was a man full of the greatest benevolence, and was ever performing acts of kindness to rich and poor, old and young alike. When they considered his life they could not but be struck with the extraordinary fulness of it. They knew Sir Frederick at the Royal Society, the Royal Institution, the British Association, and the Society of Arts, and each of those institutions, he was sure, would concur with him when he said that Sir Frederick's death left a blank that could never be filled. Of all the institutions he ornamented he loved none so much as this. On a melancholy occasion such as that it was a great satisfaction to be able to look back on the great work of benevolence which he did for members in the initiation of the Benevolent Fund. He was never weary of helping young men along the road he had travelled. They had, he was glad to say, the pleasure of looking back on his life as a very happy one; and in lamenting his loss it must be a satisfaction to those who loved him that the end had come as he had wished. He was in harness, happy in his work, and still occupied with the things he loved best.

A memorial service, held on the 4th December at St. Margaret's Church, Westminster, was largely attended by members of the Institution and representatives of many learned and scientific societies.

CHARLES DAWNEY, younger son of the late Mr. William Dawney, of Brighton, died at his residence, Calle Billinghurst 2050, Buenos Aires, on the 9th December, 1903, in his sixty-eighth year. Born on the 21st January, 1836, he began his engineering career under Mr. Thomas Deane on the South Eastern Railway from 1852 to the end of 1854, after which date he served as an Assistant to Messrs. Easton and Amos, preparing plans, sections and estimates for waterworks. He also prepared working drawings of paying-out apparatus and testing apparatus for the first Atlantic Cable, 1857–58. After acting as Resident Engineer on the construction of the Torquay Waterworks, and on the Goldstone bottom works, reservoirs, etc., of the Brighton Waterworks, Mr. Dawney was engaged in 1866 by Messrs. Easton and Amos to superintend the construction of the first Buenos Aires water-supply as Resident Engineer, and was subsequently employed by the Argentine Government.

Between 1870 and 1877 he acted as Engineer-in-Chief on the construction of the following works:—Buenos Aires and Belgrano Tramway and macadamized roads, Buenos Aires and Flores Tramway and roads, Belgrano Waterworks, and La Plata Waterworks. From 1878 Mr. Dawney practised on his own account in Buenos Aires. At the time of his death he was Managing Director of the Buenos Aires Gran Nacional Tramway Company, of the San Nicolas Waterworks Company and of the San Fernando Waterworks Company.

Mr. Dawney was elected a Member of the Institution on the 5th May, 1885.

CHARLES JOHN GALLOWAY was born on the 25th April, 1833, and was apprenticed to his uncle and father, W. & J. Galloway in 1846, becoming a partner in the firm of W. & J. Galloway & Sons, Mechanical Engineers, in 1859. On the formation of the firm into a limited company in 1889 he was appointed Chairman, which position he occupied up to the time of his death. Mr. Galloway was also Chairman of the Vulcan Boiler Insurance Company, a Director of Brunner, Mond and Co., the Carnforth Iron Company and the Manchester Ship Canal Company, and a member of the Manchester Board of the Commercial Union Assurance Company and of the Mond Nickel Company.

At the commencement of the Volunteer movement he took an active interest in it, eventually retiring with the rank of Captain

in the 40th Lancashire (3rd Manchester) Rifle Volunteers, now the 4th Volunteer Battalion Manchester Regiment. He took a great interest in International Exhibitions, and for his services in connection with the Paris Exhibition of 1878 he was made Chevalier of the Legion of Honour, and at the conclusion of the Paris Exhibition of 1889 he was promoted to the rank of "Officier." He was Vice-Chairman of the Manchester Jubilee Exhibition in 1887. Mr. Galloway had a collection of valuable pictures, including fine examples of G. F. Watts, R.A., E. J. Gregory, R.A., G. Clausen, and other artists. He was a Magistrate for the City of Manchester and for the County of Chester. He died at his residence, Thorneyholme, Knutsford, Cheshire, on the 14th March, 1904, in his seventy-first year.

Mr. Galloway was elected a Member of the Institution on the 2nd March, 1886.

EDWARD BALDWIN JOHN KNOX, who for some time previous to the war in South Africa acted as Honorary Secretary to the local Advisory Committee of the Institution, died at Johannesburg, Transvaal, on the 5th December, 1903. Born on the 6th October, 1845, he obtained his preliminary training as a pupil of Messrs. John Penn and Sons, Mechanical Engineers, of Greenwich. Subsequently he was engaged as Assistant Engineer and Manager to the Croscombe Lead and Chemical Works, Somersetshire, and as an Assistant Engineer on the staff of the late Sir Joseph Bazalgette, Past-President, at the Metropolitan Board of Works. From 1872 to 1876 he acted as Confidential Assistant to the late Mr. Thomas Elliot Harrison, Past-President, on railway works and on the Hartlepool and Tyne Docks extensions.

In 1876 Mr. Knox went to South Africa, where he practised privately for over seventeen years. During that period he carried out extensive architectural works, and also the Paarl, Wellington, and other waterworks. He was Consulting Engineer to the Municipalities of Cape Town and Worcester, and to several mines in the Johannesburg and Barberton Districts. He was also a Member of the Transvaal Commission on Technical Education and President of the Transvaal Association of Architects.

Mr. Knox was elected an Associate of the Institution on the 2nd February, 1875, was subsequently placed among the Associate Members, and was transferred to the class of Members on the 28th March, 1893.

WALTER SIMPSON McCLELLAND, second son of Mr. James McClelland, of Glasgow, was born in that city on the 29th November, 1833. He was educated first at Hofwyl, near Bern in Switzerland, and afterwards at Queenwood College, Hants. After studying at Freiburg in Saxony, with the intention of becoming a Mining Engineer, he was apprenticed to Mr. Neil Robson, of Glasgow, with whom he remained till 1854, when he joined the Army Works Corps as third in command and went to the Crimea, where that corps was employed in making roads and a light railway between Balaclava Harbour and the English camps. In 1856 Mr McClelland returned home, and the Army Works Corps being broken up, he obtained a post on the Great Indian Peninsula Railway, then in course of construction, and went to Bombay. In 1863 he left the Railway, and went into business in Bombay, the firm being Messrs. Scott and McClelland. They carried on several important works in Bombay, notably the beautiful Elphinstone Circle. In 1869 Mr. McClelland returned home. Some monetary losses, however, obliged him to resume work, and in 1877 he took service with one of the native princes of Kathiawar, the Jam Sahib of Nowanagar, with whom he remained till the death of His Highness in 1895. He did much for the State, improving the towns and harbours, making roads and bridges, building schools, repairing tanks, etc., and planning a railway, since carried out, connecting Jamnagar with the rest of the Province. His last important work was the Victoria Bridge, close to Jamnagar. In 1881 he had built a larger bridge over the Machhu river for the Thakore Sahib of Morvi, and for the Rao of Cutch he constructed a breakwater at Mandvi, and a bridge spanning the Rukmawati river and connecting Mandvi with Bhuj, the capital. On leaving India in 1896 Mr. McClelland settled at Sevenoaks, in Kent, where he was made a Justice of the Peace and Chairman of the Sevenoaks Bench of Magistrates. He was also a Fellow of the Royal Institute of British Architects. He died at Sevenoaks, from pneumonia, on the 1st of January, 1904.

Mr. McClelland was elected a Member of the Institution on the 3rd December, 1867.

HENRY WILLIAM PEARSON, born at Forest Gate on the 6th January, 1846, was educated at Bow Grammar School. He served an apprenticeship from 1862 to 1867 to the Great Eastern Railway Company, first under Mr. Robert Sinclair and subse-

quently under Mr. S. W. Johnson; from 1867 to 1870 he was engaged as a draughtsman in the Company's Locomotive Department, and from 1870 to 1872 he acted as an assistant in the Engineer's Department.

In February, 1872, Mr. Pearson was appointed Assistant Engineer to the Bristol Waterworks Company under Mr. Thomas Bell, whom he succeeded in 1874 as Resident Engineer, which post he held until his death on the 20th October, 1903. During the time he held this appointment the Company's supply was more than doubled, being now eight million gallons per day for a population of 350,000, with 300 miles of distributing mains. To meet this large increase in the consumption extensive works have from time to time been constructed; these include reservoir and extensive pumping power in the Yeo Valley, from the design and under the direction of Messrs. T. and C. Hawksley; also reservoirs at Barrow Gurney with a filtration system of six acres of sand area, and wells and large pumping power at Chelvey from the designs and under the direction of Messrs. Taylor, Sons, and Santo Crimp.

Mr. Pearson was a Member of the Institution of Mechanical Engineers and of the Iron and Steel Institute, a Member of Council of the Association of Waterworks Engineers, Past-President of the Bristol Engineering Society, a Fellow of the Geological Society, a prominent Freemason, and a member of the Bristol Madrigal and other musical societies.

He was elected an Associate of the Institution on the 14th April, 1874, was subsequently placed among the Associate Members, and was transferred to the class of Members on the 23rd November, 1886.

WILLIAM SHIPP, born on the 21st January, 1845, began his engineering career as a pupil of Mr. Harold Smith, at that time Superintending Engineer of the Elphinstone Reclamation Company, Bombay. He was subsequently engaged during 1866 on the Back Bay Reclamation Company's works in Bombay, and in the following year he entered the service of the Great Indian Peninsula Railway Company as an Assistant Engineer. He rose through the various grades to be Deputy Chief Engineer of the Great Indian Peninsula and Indian Midland Railways, now amalgamated, his headquarters being at Jhansi. Mr. Shipp died at Byculla, Malden, Surrey, on the 6th March, 1904.

He was elected a Member of the Institution on the 4th February, 1896.

SIR JOSEPH WILLIAM TRUTCH, K.C.M.G., died at Hartrow Manor, Taunton, Somerset, after a long illness, on the 2nd March, 1904. The elder surviving son of the late Mr. William Trutch, of Ashcot, Somerset, a solicitor, he was born at Bath on the 18th January, 1826, and was educated at Mount Radford College, Exeter. Soon after leaving school he became a pupil of Sir John Rennie, under whom he was engaged on railway and other work. In 1849 he accepted an engagement to proceed to San Francisco, California, to erect some iron warehouses, on the completion of which he went in the following summer to the then Territory, now State, of Oregon, where he was occupied on surveying work for the American Government. When gold was discovered in British Columbia, he moved to that colony, and engaged in surveying work, and later in road construction contracts, especially on the wagon road to Cariboo through the cañon of the Fraser River, across which he constructed the Alexandra wire suspension bridge. In 1864 he was appointed Chief Commissioner of Lands and Works and Surveyor-General and a member of the Executive Council in British Columbia, at that time a Crown Colony. In 1870 he was one of the delegates appointed to confer with the Government of Canada as to the terms on which British Columbia should be admitted into the Dominion. On the admission of the colony to the Canadian Confederation he was appointed by the Dominion Government in July, 1871, Lieutenant-Governor of the new province, and during his governorship a great deal of work devolved on him in initiating and organizing the new system of government. On the expiration of his term as Lieutenant-Governor he came to England, where he resided until 1879, when, on the return to power of Sir John Macdonald, he became Resident Agent of the Dominion Government in British Columbia until the position lapsed in 1889. Shortly after he returned to England, and, though he subsequently made several visits to British Columbia, he resided for the last few years of his life in his native county of Somerset. He was decorated with the Companionship of the Order of St. Michael and St. George in 1877, and promoted to be K.C.M.G. on his retirement in 1889. Sir Joseph Trutch was a Fellow of the Royal Geographical Society and a Member of the Canadian Society of Engineers. He married, in 1855, Julia Elizabeth, daughter of Mr. Louis Hyde, of Batavia, New York, U.S.

He was elected a Member of the Institution on the 4th April, 1871.

EDWARD RUSH TURNER, who died at his home, near Ipswich, on the 10th February, 1904, was one of the pioneer engineers who helped to build up the great trade in agricultural and milling machinery which this country enjoys. Born in December, 1823, he was the son of Mr. Walton Turner, a leather merchant, and after serving a pupilage to the firm of Bond, Turner and Hurwood, he was sent to Messrs. Wren and Bennett, of Manchester, to learn general engineering and mill-wrighting. From 1847, in partnership with Mr. Hurwood, he carried on the business at St. Peter's Works, Ipswich, and on the retirement of Mr. Hurwood in 1851, after conductiing the business alone for a time, he ultimately took into partnership his brother, Mr. Frederick Turner, and established the firm which now enjoys a wide reputation. The company was successful practically from the first, and the works were rapidly developed. The subject of this notice took great interest in mills of all kinds for the crushing of cereals, and was an active competitor in the trials of the Royal and Smithfield shows. The manufacture of all kinds of implements was also undertaken. In traction-engine work also Mr. E. R. Turner interested himself, and he is credited with the invention or introduction of the extension of the fore part of the boiler, so arranged that the fore-carriage might swing through a large arc.

While actively engaged in this work Mr. Turner found time to devote to municipal matters, and it is largely to his efforts that the present extensive sewer system of Ipswich is due. On the death, in 1864, of Mr. Hurwood, who had held the office of Engineer to the Dock Commission from the time of the construction of the dock, Mr. Turner was appointed his successor, and his relinquishment of the post after seven years' service was due solely to the increasing claims of private business. He served the office of Mayor in 1882.

Mr. Turner was elected an Associate of the Institution on the 5th December, 1865, was subsequently placed among the Associate Members, and was transferred to the class of Members on the 1st April, 1879. Not long before his death he was enrolled as an Honorary Life Subscriber.

HENRY BARRATT, born at Heaton Norris in February, 1840, entered the service of the North Cheshire Water Company at the age of 20, and in 1869 was appointed Manager to that Company, which post he held until his death. He acted also for some years as Engineer to the Knutsford Gas and Water Company. For forty-

three years he was connected with the Newtown Night Mission, the flourishing condition of which is largely due to his untiring exertions; he was also for some time Chairman of the Altrincham Free Library and Technical Instruction Committee, and he was largely interested in charitable work for the poor of the district.

Mr. Barratt was elected an Associate of the Institution on the 3rd February, 1874, and was subsequently placed in the class of Associate Members.

GEORGE HENRY COBB, born in 1832 at Bredgar, Kent, served his pupilage in the works of Messrs. John Penn and Son at Greenwich, with which firm he subsequently remained for nine years, being chiefly occupied in the drawing office. In 1863 he was appointed Chief Engineer to the Arsenal at Triest, and after holding that post for a time he went to Peru as Naval Engineer to the Peruvian Government. About the year 1873 he gave up active pursuit of the profession and from that time lived in retirement in England, although he took keen interest in engineering matters until his death, which took place at Tunbridge Wells on the 26th February, 1904.

Mr. Cobb was elected an Associate of the Institution on the 12th January, 1864, and was subsequently placed in the class of Associate Members.

WILLIAM FREDERICK CRAWFORD, B.A. (*Dublin*), died at Johannesburg, Transvaal, on the 8th October, 1903, from pneumonia. Educated at Trinity College, Dublin, where he graduated in Arts and Engineering, he gained his early engineering experience in the works of Messrs. Emerson and Murgatroyd, at Stockport. In 1863 he went to India as Assistant to the Madras Irrigation and Canal Company, and subsequently acted as Engineer during the construction of the Kurnool and Cadapa Canal. He then acted for four years as Agent for Messrs. Wythes and Jackson on the construction of the Maritzburg and Durban Railway, in Natal, and afterwards undertook a contract to supply the labour required to construct the Kimberley Waterworks. Subsequently he constructed the Karachi Steam Tramways and worked them for some months. On the completion of that undertaking he returned home and was engaged for some years in reporting on various mines and in studying the chemical analysis of minerals. Latterly he was in business in Johannesburg as Consulting Engineer. Able as an engineer, he was modest, geni

and generous in disposition, and always ready to help those in need, and his loss was much regretted in Johannesburg.

Mr. Crawford was elected an Associate of the Institution on the 3rd May, 1870, and was subsequently placed in the class of Associate Members.

FREDERICK DRESSER, born on the 4th June, 1843, was educated at Merchant Taylors' School and at Cheltenham College. He was apprenticed first to Messrs. Humphrys, Tennant and Co., of Deptford, and subsequently to the Greenock Foundry Company. After a voyage to the West Indies as engineer, he entered the Indian Public Works Department in March, 1868, and was employed on the Apollo Bunder, at Bombay, and on works at Carwar, as Assistant Engineer First-grade. When in England on leave in 1871 he married Jane, eldest daughter of Sir Thomas Brocklebank, Bart., who returned to India with him, but as he found that the climate there did not agree with his wife, he gave up his appointment, returned to England, and commenced business as a rice miller at Bixteth Street, Liverpool. On his business being acquired by Messrs. White, Tomkins and Courage he became Managing Director of the local branch of that firm, continuing as such until his death, which took place suddenly on the 31st of March, 1903.

Mr. Dresser was elected an Associate of the Institution on the 6th December, 1870, and was subsequently placed in the class of Associate Members.

BARROW EMANUEL, M.A. (*Dublin*), died at his residence, 147 Harley Street, W., on the 14th February, 1904, aged 62. Born at Portsmouth on the 4th February, 1842, he served a pupilage to Mr. H. Wood, Superintending Civil Engineer of Portsmouth Dockyard, and was subsequently articled to Messrs. George Rennie and Sons, of Holland Street, Blackfriars. After graduating in arts at Trinity College, Dublin, he acted for two years as Chief Draughtsman to Messrs. Lewis and Stockwell, shipbuilders and dry-dock owners, of Blackwall.

In 1867 he became a member of the firm of Davis and Emanuel, in which he was senior partner at the date of his death. During that period of thirty-seven years the firm carried out works at Southsea Pier and in connection with the Portsmouth Street Tramways, and were the architects of the City of London School, the London Hospital Convalescent Home at Felixstowe, the Yarrow Con-

valescent Home at Broadstairs, and Salisbury House, as well as of many other buildings in the City and in the West End. For many years Mr. Emanuel was the architect to the East End Dwellings Company. He was on the committee of many benevolent institutions, a member of the Jewish Board of Guardians, of the Loriners' Company, and of the Court of the Patten Makers' Company, a Justice of the Peace for Middlesex, and a well-known member at the Reform and Savage Clubs.

Mr. Emanuel was elected an Associate of the Institution on the 5th December, 1871, and was subsequently placed in the class of Associate Members.

EUGENE KINNAIRD HASELDEN, born on the 30th March, 1845, was for some years employed at the Seville Gas Works under his father, Mr. Henry Haselden. In the year 1870, finding mining work more congenial to his taste, he went to Linares and for several years was Under Manager at the Collado del Lobo Mines. From Linares he went to La Carolina to undertake the management of the group of mines known as the Cura Mines; which under his direction were most successfully worked. He was also appointed Manager of the Culebrina Mines, which at the time were in difficulties; these he overcame, and placed the mines in a very favourable position. He was also at the time of his death, which took place at La Carolina on the 19th January, 1904, Joint Manager with his brother, Mr. Arthur Haselden, of the Centenillo Silver Lead Mines Company.

He was elected an Associate Member of the Institution on the 1st February, 1898.

JOHN DAVY POSTLE died at his residence, Glebe Point, Sydney, New South Wales, on the 17th November, 1903. Born on the 1st December, 1839, he received his early training in the locomotive works of Messrs. Robert Stephenson and Company, and in 1860 emigrated to Australia, where for some years he was engaged in mining work and in the design and construction of refrigerating machinery. In 1878 he joined the Roads and Bridges Branch of the Public Works Department of New South Wales, and in the following year was appointed Roads Superintendent at Bourke in the Western District. In 1882 he was transferred to Bega in the south as Roads Superintendent, and in 1891 was appointed Resident Engineer for that district. He retired from this appointment in 1895 on a pension. Whil

located in the southern part of the Colony he carried out an extensive mountain road between Colombo and Cooma, crossing what is known as Brown Mountain, to connect the south eastern portion of the Colony with the Cooma railway terminus.

Prior to entering the Works Department Mr. Postle had paid great attention to refrigeration, and in 1868 took out a patent for an expansion cylinder used in conjunction with a compression cylinder to form a dry-air refrigerating machine. He subsequently took out other patents in connection with this matter, and also carried out a number of experiments which demonstrated that the effect of moisture in the atmosphere had a greater influence upon the length of time which frozen meat would keep than mere differences in temperature.

Mr. Postle was elected an Associate Member of the Institution on the 3rd December, 1889.

DAVID McTAGGART SYMMERS, M.A. (*Aberdeen*), died in Aberdeen on the 20th August, 1903. Born on the 14th January, 1870, he was educated at Gordon's College and at Aberdeen University, where he graduated in arts in 1893. After serving a pupilage to Mr. Patrick M. Barnett, he was appointed an Engineering Assistant on the staff of the Great North of Scotland Railway, on which he was engaged until 1899, when he entered the service of the Aberdeen Harbour Commission, under Mr. R. Gordon Nicol, the Engineer-in-Chief. Under Mr. Nicol he was employed in various works of improvement at the Port of Aberdeen, including the construction of timber wharves, masonry quay walls with cylinder foundations, the reconstruction works of Regent Bridge, and Point Law Improvement Works. He was a most reliable and trustworthy engineer, conscientious and scrupulously accurate in all his work. He took great interest in the local engineering and scientific societies, and contributed in 1902 a Paper on "The Stresses in Masonry Arches" to the Aberdeen Association of Civil Engineers, of which he was a member.

Mr. Symmers was elected an Associate Member of the Institution on the 2nd April, 1901.

HENRY ANDREW VIVIAN, born at Camborne, Cornwall, on the 31st January, 1824, obtained his early engineering training in a mine in Devonshire, where he remained for about two years. He then became Land and Mineral Agent and Manager of an

estate at Eagle Hall, Pateley Bridge, Yorkshire, which post he held until 1858, when he obtained an appointment under Mr. Vignoles, Past-President, as an Assistant Engineer on the Bahia and San Francisco Railway. In June, 1860, he went to Chili in the service of the Copiapo Smelting Company, and after eighteen months was appointed Engineer for the Copiapo Railway extension from Pabellon to Chanarcillo. In October, 1864, he became Manager and Engineer of the Coquimbo Railway, which post he held until 1896, when the line was purchased by the Chilian Government. During his management there occurred a tremendous flood, which swept away a large number of the bridges and viaducts of the railway. The stone piers were entirely demolished, nothing being left but the rails, kept together by the fish-plates. When he reconstructed this portion of the line he used the old rails for some of the piers, and those piers are still standing, although several floods have occurred since, the stone piers erected at the same time being swept away. He returned in 1898 to England, where he remained until his death, which took place at Falmouth on the 25th January, 1904.

Mr. Vivian was elected an Associate of the Institution on the 1st December, 1868, and was subsequently placed in the class of Associate Members.

ROBERT MARTIN BARKLIE, *Colonel* R.E. *retired*, who died at his residence, Inver, Larne, Ireland, on the 30th August, 1903, was the only son of the late Mr. Thomas Barklie, of Inver. Born on the 30th January, 1846, he was educated at Trinity College, Dublin, the Royal Military Academy, Woolwich, and the School of Military Engineering, Chatham. Gazetted to the corps of Royal Engineers in July, 1867, he was employed from 1872 to 1874 on the construction of sea defences in British Guiana, from 1875 to 1877 on the reconstruction of brigade depot buildings at Ayr and Paisley, in 1878 on the water-supply to Curragh Camp, and from 1879 to 1884 on the Ordnance Survey. In 1884–85 Captain Barklie, as he then was, took part in the Sudan Expedition, for which he received the medal with clasp and bronze star. He was in charge of the construction of Marlborough Barracks, Dublin, from 1889 to 1894, and of Mustapha Pacha Barracks, Alexandria, from 1895 to 1898.

In 1898 he became Colonel on the staff, and Commanding Royal Engineers of the Southern District, and in 1901 was placed in command of the Salisbury Plain District, where he rendered valuable service in connection with the large barracks in course

of erection on the Plain. He was placed on the retired list, under the age regulation, on the 30th January, 1903.

Colonel Barklie was elected an Associate of the Institution on the 3rd December, 1901.

FRANCIS MURRAY NEWTON, born in 1852 at Barton Grange, Taunton, was educated at Eton and at University College, Oxford. Taking up astronomical work, he was attached to the Government expedition to Egypt, to observe the Transit of Venus, which he did from Cairo on the 8th December, 1874. On his return to England he went through the works of Messrs. Easton and Anderson, at Erith, and in 1879 he became a master at Eton, being placed in charge of the Practical Mechanics Department. After two years of this work ill-health compelled him to resign. Ultimately he started electrical works in Taunton, and after a time erected the works close to Taunton Station, now known as the Newton Electrical Works, of which, on the formation of a Limited Company, he was appointed Managing Director. Mr. Newton died suddenly at Lancaster on the 16th August, 1903.

He was elected an Associate of the Institution on the 4th February, 1879.

⁂ The following deaths have also been made known since the 4th February, 1904:—

Members.

Anderson, Archibald Miles; *died* 23 March, 1904.
Cotton, Charles Philip; *died* 10 March, 1904.
Dawson, Ernest Frederick; *died* 7 April, 1904.
Elsdon, William; *died* 10 March, 1904.
Field, Joshua; *died* 29 April, 1904.
Langley, Alfred Andrew; *died* 18 February, 1904.
Luff, John Middlemiss; *died* 6 March, 1904.
Mérie, Leopold Dollfus de; *died* 15 March, 1904.
Pearson, Thomas William; *died* 30 March, 1904.
Spalding, William Henry; *died* 8 March, 1904.
Stewart, Houston Stewart; *died* 4 May, 1904.
Wilson, James; *died* 13 April, 1904.

Associate Members.

Eden, Joseph; *died* 25 April, 1904.
Gorman, William Augustus; *died* 4 February, 1904.
Minami, Kiyoshi; *died* 20 January, 1904.

Associates.

Forbes, James Staats; *died* 5 April, 1904.
Hargrove, James Sidney; *died* 9 April, 1904.

Information as to the career and characteristics of the above is solicited in aid of the preparation of Obituary Notices.—Sec. Inst. C.E., 10 May, 1904.

Sect. III.

ABSTRACTS OF PAPERS IN SCIENTIFIC TRANSACTIONS AND PERIODICALS.

Consolidation Works in Underground Quarries on the Paris Metropolitan Railways. Wickershaim and Weiss.

(Annales des Mines, vol. iii., 1903, p. 587.)

This is a continuation of a former memoir on the same subject[1] describing the works necessary for the protection of the Sceaux line extension by Mr. Keller in 1889. In 1894 the old quarries were estimated as covering about 10 per cent. of the area within the walls, but subsequent researches have shown this to be too small, and that it is more likely to be between one-fourth and one-third. In the Southern Circular line No. 2, to which the present communication refers, the line for a distance of about 3½ miles is almost continuously underlain by old quarries at depths varying from 8 metres to 23 metres below the surface-roads or 1 metre to 15 metres below the rail-level, rendering necessary a large amount of consolidation work, which had to be carried out in a comparatively short time, so that the methods adopted, while similar to those of the former work, were of a more expeditious character, especially as regarded the central gallery, which, instead of being kept to the exact direction of the axis of the railway, was deflected when necessary to pass obstacles such as pillars, old bell-pits, etc., returning to the general line when possible. Where the roof of the old quarry is sound, the support is given by transverse walls, 1·40 (4·6 feet) metre wide, spaced 4 metres (13 feet) apart from centre to centre with a central gallery 1·40 metre wide; the maximum length supported being 9·6 metres under the running-line tunnel which is 8·6 metres broad, something more than double that amount being adopted under the station tunnels. Where, however, the roof is heavily degraded and in bell-pits the works are carried up to the tunnel invert, which is supported on arches carried by pillars either of masonry or concrete filled into shafts sunk into the rubbish. Where the extent of broken ground is small it has been found sufficient in many cases to give support by a ring of masonry 1 metre (3·28 feet) in thickness, but for large masses the method by concrete-filling was necessary. This happened in forty-eight instances, the simpler method having

[1] Minutes of Proceedings Inst. C.E., vol. cxxiv. p. 473.

sufficed in thirty-nine other cases. One specially dangerous pit encountered below the tramway terminus in the Boulevard Vaugirard was found to be only partially filled with loose rubbish, and to extend to a height of 13·45 metres (44 feet) above the quarry floor. This was secured by provisional timbering and building up with burr stone masonry. The total volume of the cavity was 650 cubic metres (850 cubic yards) and that of the masonry put in 450 cubic metres (588 cubic yards).

The works, which were done by contract in twelve months, were let in six different lots, at prices varying from 16·4 per cent. to 23·2 per cent. discount on the engineer's estimate. In four of these the work was done by shafts 2·4 metres by 2 metres (7·87 feet by 6·56 feet) with steam or electric hoists sunk at distances averaging about 200 metres apart. In the other two, smaller circular pits with hand-windlasses were used, but in greater number, the average interval being only 65 metres. The latter system the Author considers to have been the more advantageous to the contractors.

In the course of the works about 70,000 cubic metres (9,156 cubic yards) of ground were excavated, and 7,000 cubic metres of packing and 45,000 cubic metres of masonry were built in; 1,400 cubic metres of oak, 1,200 metres of pine wood, 21,000 square metres of planking and 37,000 lineal metres of squared timber were consumed in the mining work, the working force averaging about 500 per day.

The total cost amounted to £74,312. The cost of the finished masonry (stone and concrete included) was 41·20 francs per cubic metre (25*s.* per cubic yard). In the Sceaux line works in 1892 it was 64·28 francs (37*s.* per cubic yard). In spite of the essentially dangerous character of the works they have been completed without a single fatal accident.

H. B.

New York Rapid-Transit Railway.

(Engineering News, 1 and 8 October, 1903, pp. 289 and 308.)

An exhaustive series of articles has appeared in this periodical descriptive of the above railway.

The standard construction of subway first consisted of two rectangular subways, 12 feet 6 inches wide by 13 feet high, inside measurement, with a row of columns built up with four angle-bars and web-plate between the two. The cross-section was first built with ⊢⊣ beam columns in the walls, with concrete jack arches between them, and roof beams also connected by arches. This form of construction was changed near the Harlem River for the remainder of the work, the shape being kept the same, but, instead of the columns in the side walls and roof beams, two angles riveted together to form a T, with its flat face towards the inside, are spaced 5 feet apart in the side walls, and two 1¼-inch round rods

in the roof connect these angles to the columns between the two subways, and similar rods connect the tops of the angles and of the columns longitudinally. Vertical steel rods, 12 inches apart, are also embedded near the flat surface of the side walls and wired to similar rods across the roof and floor, the whole being embedded in monolithic concrete of suitable thickness. To render the latter watertight is a waterproof lining at the outside, consisting of layers of asphalt paper and asphalt with bricks laid in hot asphalt inside of these.

For a length of 610 feet, including the crossing of the Harlem River, the tunnel consists of two intersecting circles of cast-iron segments, the internal radius of which is 7 feet 6 inches, with a vertical cast-iron diaphragm at the intersection of the two circles. A considerable thickness of concrete surrounds these tubes. To construct the latter the bed of the river was dredged down to about the centre line of the tunnel. Four rows of piles were driven about 6 feet between centres transversely, and 8 feet between centres longitudinally, over the area to be occupied by the tunnel, to assist in supporting the timber roof about to be described, and, afterwards, to be cut off at the proper level to aid in supporting the finished structure. Then a line of 12-inch close sheet-piling was driven on either side, at the right distance apart, to allow the tubes and the surrounding concrete to be built between, and cut off at the proper level to support the roof, consisting of three layers of 12-inch baulks, separated by 2-inch tongued and grooved planks, running at right angles to the latter. The two series of sheet-piling were kept in alignment by a substantial pile platform on either side of the tunnel site, used as surface platforms during the construction of the tunnel, and by a timber frame constructed to fit accurately between the two lines of sheet piling and sunk in the correct position, so as to form a guide for driving these piles. To ensure accuracy in the position of the latter, steel pilot piles were first driven by the water-jet method to ensure there being no boulders in the way, and then withdrawn for the wooden piles to replace them.

The roof was covered with about 5 feet of earth or mud. A bulkhead was constructed at each bank of the river and in the middle, in order that compressed air might be used during the construction of the tunnel inside the chamber thus formed.

A. W. B.

The Pennsylvania Railway Tunnel under the North River at New York City.

(Engineering News, 15 and 29 October, 1903, pp. 331 and 393.)

The proposition of the Pennsylvania Railway Company to tunnel under Manhattan Island and the two great waterways which bound it on the east and west involves the construction of a

tunnel 5¾ miles long, partly on land and partly under water, and through one of the most unstable materials ever encountered in subaqueous tunnelling. The work is under the general direction and management of the railway, who appointed a board of consulting engineers to whom were assigned the various parts of the work. The tunnel is to start from North Bergen on the west side of New Jersey bluffs, then pass under the North River, Manhattan Island, and the East River to Long Island. Starting from North Bergen, there are 6,290 feet of twin single track tunnels; twin tube tunnels extend across the North River, of which 5,947 feet is subaqueous; it emerges on Manhattan Island as a two-track tunnel, and for part of this division it is a three- and for part a four-track tunnel; but before reaching the East River it again becomes twin single-track tunnels with concrete or brick and concrete linings. Under the East River they consist of twin single-track cast-iron lined tubes; after crossing the East River they continue as two single-track tunnels, but lined with concrete or brickwork, which converge until they meet in open cutting. Shafts are provided for at convenient places. The two single-track tunnels under Bergen Hill are 37 feet apart, centre to centre; they have concrete side walls and brick arch with layers of felt and coal-tar on the outside to make them waterproof.

The cast-iron tubes are for the most part carried on 27-inch screw-piles, spaced 15 feet apart; these tubes are made very stiff by a thick lining of concrete. Each cast-iron ring is 30 inches long and made up of twelve segments with flanges 11 inches deep. The bored segments through which the screwed piles pass are of special construction, made of cast steel, and placed at the bottom of the tube. The screw-piles are provided with a helix of one turn, with a pitch of 21 inches. After they are driven, the top length is removed and a special section of the proper length is inserted, its junction with the tunnel being made watertight.

The four-track portion of the tunnel is laid with wall columns spanned by bow-string roof trusses, spaced 5 feet apart. The columns and the top chord of the roof truss are embedded in a concrete lining. Steel columns and girders also enter into the construction of the triple tunnel.

A. W. B.

Locomotives of the Rhätischer Railway in Switzerland.

(Schweizerische Bauzeitung, 1903, vol. xlii., p. 99. 9 Figs.)

On the opening of the Reichenau-Ilanz and Thusis-Celerina branches of the Rhätische line it was necessary to increase the number of locomotives, and therefore six tank locomotives and eight Mallet locomotives were ordered from the locomotive works at Winterthur. These engines are fully described and illustrated. The tank engines were required to draw a train of 45 tons weight,

exclusive of the engine, up an incline of 4·5 per cent., at a speed of 9·3 miles per hour; while the Mallet engines required to draw a train of 70 tons, exclusive of the engine, up the same incline, at the same speed, and these stipulations were successfully fulfilled.

The former class were of the "Mogul" type, with outside frames and outside cylinders, with six coupled wheels and a leading two-wheeled bogie. The leading dimensions were:—gauge, 1 metre; diameter of cylinder, 13·4 inches; stroke, 19·68 inches; diameter of wheels, 41·3 inches; steam-pressure, 180 lbs.; weight empty, 21 tons; weight loaded and with snow-plough, 34 tons.

The Mallet engine has already been fully described and therefore the following data will suffice:—gauge, 1 metre; diameter of high-pressure cylinders, 12·4 inches; diameter of low-pressure cylinders, 19·3 inches; stroke, 21·6 inches; diameter of driving-wheels, 41·3 inches; steam-pressure, 210 lbs.; weight empty, 38 tons; weight in working order with snow-plough, 45 tons. There are two sets each of four coupled wheels, with outside frames and outside cylinders. Both types are fitted with Walschaert valve-gear, and have given satisfaction. An illustration of the older type, which they have superseded, is also given.

E. R. D.

The Ofot Railway, Norway. A. Fleischer.

(Teknisk Ugeblad, Christiania, 1903, pp. 121 *et seq.*)

Under this name the Author, who is the Director of the State Railways department, describes the Norwegian section of the railway, which, on crossing the frontier into Sweden, is known as the Gellivara Railway,[1] running through the Gellivara iron-ore mining district to the port of Luleå in the Gulf of Bothnia. It was opened by the King on the 14th July 1903. The total length from Narvik Harbour up to the frontier is 42·55 kilometres (26·44 miles). The harbour, intended for general traffic, having a railway wharf with a 20-ton crane, is at the inner or southern extremity of Narvik Bay, which is always free from ice, faces west, and opens out into the Ofot Fjord. The ore-shipping quay is at the outer or northern extremity of the bay; adjoining are extensive sorting grids, whereon the trucks of the ore trains arriving from Sweden are sorted according to quality of ore, in readiness for shipment at the quay. Large storage bins and a yard are also provided behind the grids, with a view to saving a steamer from having to wait for an ore-train delayed on the way. Round the head of the bay runs a loop line connecting ore-quay and harbour. An intermediate station at Kleven has a landing-stage already used for passenger traffic, with a wharf and coal-stores for the adjacent loco-

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[1] Minutes of Proceedings Inst. C.E., 1903, vol. clii. p. 346.

motive shed and workshop, and with room for a future ore-quay. A second locomotive-shed, workshop, and coal-store adjoin the sorting-grids. Three branch lines—from the storage-bins and yard, from the ore-quay and sorting-grids, and from the harbour and Kleven—form a junction at Narvik station, at the northern end of the town that is being laid out between the junction and Kleven. Two separate storage-reservoirs supply water to the town and to the railway.

From 5·83 metres (19 feet) above sea-level at Narvik Harbour the rail-level rises continuously up to 522·09 metres (1,712 feet) at the frontier; the mean gradient is consequently 1·21 per cent., or 1 in 82. The maximum gradient is 1·73 per cent., or 1 in 58. The line is single, with seven level turn-outs long enough for allowing trains of 350 metres (1,148 feet) length to pass each other. The minimum radius for curves is 300 metres (984 feet), and no curve is longer than 100 metres (328 feet).

Where the railway needs protecting against stone-runs, it is roofed over with masonry to the same section as the tunnels, namely 5 metres wide by 5·82 metres high ($16\frac{1}{2} \times 19$ feet) with a semicircular arch; the whole is covered with rubble stone, paved over at a slope of 1 in 4 with a steep fall over from the foot of the slope to ensure a free run.

Steel rails, 40 kilograms per metre (80 lbs. per yard), are laid in lengths of 9 or 9·5 or 10 metres ($29\frac{1}{2}$ or $31\frac{1}{4}$ or 33 feet), with thirteen or fourteen sleepers per length.

The gauge on the Norwegian side of the frontier is 1·524 metre (5 feet), and on the Swedish 1·435 metre (4 feet $8\frac{1}{2}$ inches). The difference of 89 millimetres ($3\frac{1}{2}$ inches) is met by special arrangements of the wheels and axles of the goods and ore wagons, enabling them to be transferred from one gauge to the other without shifting their loads.

A. B.

The Katterat and Norddal Tunnels on the Ofot Railway.

A. Fleischer.

(Teknisk Ugeblad, Christiania, 1903, pp. 136–7.)

Besides 3,181 metres (3,478 yards = 1·976 mile) of shorter tunnels driven by hand-labour at a cost of 261 kroner per metre (£13 5*s.* per yard), the two longest tunnels were driven by boring machines for greater expedition. These are the Katterat tunnel, 507 metres (554 yards), situated between 31 and 32 kilometres ($19\frac{1}{2}$ miles) from Narvik Harbour, and about 1,250 feet above sea-level; and the Norddal tunnel, 607 metres (664 yards), situated about 35 kilometres ($21\frac{1}{2}$ miles), and about 1,450 feet above sea-level. The cost of machine-boring was 354 kroner per metre per yard); or, including the power-station, about 406 kroner

per metre (£20 13*s.* per yard). The section of all tunnels is 5 metres (16½ feet) wide by 5·82 metres (19 feet) high to the crown of the semicircular arch.

Power obtained from a waterfall in Hundal river was transmitted by electricity to two sub-stations at the working-places. The power-house, 390 metres (426 yards) from the intake, contains a radial Girard turbine on a horizontal shaft, giving 150 HP. effective at 600 revolutions per minute, coupled direct to a three-phase alternating-current dynamo, whence ran two conductors, together 3,807 metres (4,163 yards = 2·365 miles), to the sub-stations. In each of the latter was a three-phase motor driving an air-compressor with cylinder 300 × 300 millimetres (12 × 12 inches). The welded wrought-iron air-mains together extended 2,000 metres (1¼ mile). There were twelve percussive drills, with cylinder 80 millimetres (3⅛ inch) diameter and 220 millimetres (8⅔ inches) stroke, weighing 130 kilograms (2½ cwt.); six screw-pillars and six hydraulic, and ten lengths of flexible hose. The erection of all these power appliances was carried out in the months October–February, the most unfavourable time of year; the cost of the whole was 127,760 kroner (£7,098), and all have worked well. Three drills were generally at work in each tunnel, and sometimes four. A heading was driven in advance in the bottom corner of the tunnel section, 3 metres wide and 2·3 metres high (10 × 7½ feet), which was then widened out to the full width of 5 metres (16½ feet); the rock above was brought down afterwards, partly by hand-boring. The chief causes that rendered the machine-boring so much more costly than hand-labour were the high rate at which the work had to be pushed on, and the larger quantity of dynamite used with a view to readier removal of the rock blasted: on the full area of the tunnel section the consumption per unit of length (metre or yard respectively) was 18 kilograms or 36½ lbs. for hand-boring, and 67·7 kilograms or 136½ lbs. for machine-boring; in the bottom heading it was 9·5 kilograms or 19 lbs. and 28·7 kilograms or 58 lbs. for hand and machine work respectively. With the latter the monthly rate of progress averaged 35 metres (38 yards) forwards in the heading. The rock is chiefly hard syenite and gneiss; here and there occurs mica-slate, with and without clay; and in one of the cuttings marble.

A. B.

The Norddal Bridge on the Ofot Railway. S. A. Lund.

(Teknisk Ugeblad, Christiania, 1903, pp. 169 *et seq.*)

Apart from two railway and two road bridges in Narvik, 11·6 to 34·4 metres (38 to 113 feet) long, the only importan bridge is that which carries the railway across the upper end

Norddal, 35·3 kilometres (22 miles) from Narvik Harbour, and 444 metres (1,456 feet) above sea-level.

The clear length of the bridge between abutments is 180 metres (590 feet) in ten spans of 18 metres (59 feet); the profile, or transverse sectional area of the valley beneath it, is 4,300 square metres (5,100 square yards). The superstructure, consisting of two continuous main plate-girders of I section, is carried on nine hinged trestles or pillars, each of which has two legs, straddling apart transversely to the railway line, with a batter of 1 in 8. Each leg stands on a separate stone pedestal, 2 metres (6½ feet) square at top and with sides sloping 4 to 1, capped by a single stone slab 1·2 × 1·2 × 0·7 metre (4 × 4 × 2½ feet), which carries the base-plate and hinge-pin for the pillar-leg; the whole secured by four holding-down bolts fixed in the masonry or in the solid rock beneath.

The two main girders are 2 metres (6½ feet) deep and 3 metres (10 feet) apart, made in lengths of 9 metres (29½ feet) with two half-lengths of 4½ metres (14¾ feet) at the ends of each. They are connected by transverse plate-girders 3 metres (10 feet) apart, which support two pairs of longitudinal rolled beams of I section; these again carry the transverse sleepers, over which run the rails, each rail central over one pair of the longitudinal beams. The top of the sleepers is 5 or 6 inches below the top of the main girders. Over every pillar the web of the plate-girder is stiffened by vertical angle-bar ribs, inside and outside. The girders are stiffened laterally against an assumed wind pressure of 250 kilograms per square metre (50 lbs. per square foot) by diagonal stays of + section uniting their bottom flanges; the two pairs of longitudinal beams are similarly braced together by diagonal angle-bars. At the southern end the girders are anchored to the abutment; their aggregate expansion, amounting to 200 millimetres (8 inches), is all allowed for at the northern abutment, where their ends rest on sliding shoes, and the rails are provided with expansion-joints. Along each side of the bridge runs a wooden footway with iron railing, carried on overhanging iron brackets; and also a pair of rails for a suspended inspection-car to travel along each side beneath the footway; by means of flaps the two cars can be coupled together, so as to form a single car reaching right across underneath any span.

A tabulated summary is given of the cost of the Norddal bridge, classified under the principal headings. The total was roundly 322,000 kroner (£17,890), which works out to 1,630 kroner per lineal metre (£90 per yard), and 65 kroner per square metre (£3 4*s.* 6*d.* per square yard) of the transverse vertical section of the valley crossed, abutments included. When tested under three locomotives—each weighing 70½ tons, and tender weighing 35½ tons—the maximum deflection of the main girders was 5 millimetres (0·2 inch), and the greatest compression of the [pill]ars 2½ millimetres (0·1 inch). At a speed of 40 kilometres [(25 m]iles) per hour, the lateral oscillation, of which autograph

diagrams are given, was not more than $1\frac{1}{2}$ millimetre (0·06 inch) to either side under sudden application of the brakes. Operations were begun at the bridge site at the end of July 1900, and finished at the end of August 1902; it was only during the summer months that work could be carried on there. The bridge is illustrated by eleven photographs and a number of figured drawings and details.

A. B.

Snowdrifts on the Ofot Railway, Norway. I. T. Wiull.

(Teknisk Ugeblad, Christiania, 1903, pp. 265–274.)

The construction of roofings and screens having been dealt with by Mr. Fleischer, in the Paper of which an abstract is given at p. 449, the Author describes in ample detail the principal portions of the railway which are protected by one or other of these erections, or by both combined. The description is illustrated by:—Nine photographs of the country traversed by the line, both where protected and where unprotected; a plan of the 7·3 kilometres ($4\frac{1}{2}$ miles) from Norddal bridge up to the frontier, whereon are shown all the tunnels, the existing roofings and screens, and the extensive additional protections intended; also profiles of the two worst lengths in this highest stretch of the railway; thirty sections of cuttings and embankments along the side-long ground of varying steepness; and two additional sections of roofings, supplementing the six given by Mr. Fleischer.

From the experience already gained concerning snow on the Ofot Railway, the following conclusions are arrived at:—The actual quantity of snow falling is not so important as its perpetual driving, which is the cause of the difficulties encountered. On open ground the snow drives from all quarters, thereby restricting the use of screens. Deep cuttings give less trouble than low embankments, and are therefore more easily protected by screens. The height of an embankment over open ground should be not less than 2 metres (6 to 7 feet), in order that the wind may be able to keep the rails clear. Lower embankments, whereon drift snow collects and has to be removed by plough, get snow banks thrown up alongside thereby, which pile up further accumulations, so that the line becomes worse and worse to keep clear as the winter goes on. Unless such banks can be levelled off, so as to prevent their falling in upon the railway, it will be necessary to roof over the whole length so exposed. Screens in combination with roofings are highly serviceable; they intercept the drift snow alongside a stretch of open line, and guide it over the roofings, which like bridges can be erected at the most convenient places. This is the only plan practicable on steep slopes, where as a rule the snow

drives down from the mountain side. For calculating the strength of roofings that will have to carry large masses of snow, its specific gravity can be taken at 0·4 to 0·5.

A. B.

The Swakopmund and Windhoek Narrow-gauge Railway.

VON SCHWABE.

(Annalen für Gewerbe und Bauwesen, Jan. 1, 1904, p. 17.)

This railway, in German South-West Africa, attains a total length of 237·36 miles, and merits attention in that it has been undertaken without any attempt at a preliminary survey. It was commenced in the autumn of 1897, and opened for traffic on the 1st July, 1902, and is on the model of a military light railway, with a gauge of 23·6 inches. Owing to the irregular surface of the districts traversed, vast expense would have been entailed by the provision of a railway of the normal gauge, and, in consequence of the outbreak of rinderpest, it was imperatively necessary to secure reliable means of transport to the interior with all possible speed. The railway may be described in two sections: (1) The portion of the line, carried out as a light road-railway, between Swakopmund and Karibib, without any previous survey, a length of 120·84 miles; (2) the railway from Karibib to Windhoek, for which a proper survey was made, and which contains no gradients of more than 1 in 50; whereas, in the former section, there are gradients of 1 in 50, in 40, in 37, in 30, and even a length of 2·48 miles at 1 in 20, with curves of only 38·26 yards radius. Since the line rises to a total height of 5,370 feet, it may be regarded as a mountain railway, and Windhoek, the summit station, lies higher than Zermatt. The steel Vignoles rails are laid in lengths of 16·4 feet, weigh about 19 lbs. per yard, and are fixed on iron transverse sleepers 3·93 feet in length. Although the track was designed for passenger trains covering 12 miles per hour and goods trains averaging 9 miles per hour, it is pointed out that more sleepers and heavier rails are needed for safety at this speed with the heavier engines projected. Trains with two engines and eight wagons are in common use, but the steepest gradient of 1 in 20, at Khanrevier, can only be mounted by the engines with two wagons at a time. An account is given of the rolling stock, repairing shops, passenger fares, goods rates, etc. There is at present only one passenger train weekly in each direction, and daily goods trains if necessary. The approximate annual loss on the working is £13,946 per annum. The total expenditure down to 31st March, 1902, was £700,000, or rather under £3,000 per mile.

G. R. R.

Design and Operation of Railway Sorting Yards. C. L. Bardo.

(The Railway and Engineering Review, Chicago, January 1904, pp. 52 *et seq.*)

In this Paper, read before the New York Railway Club, three systems of switching in railway sorting-yards, for the purpose of classifying railway trains, at present in vogue in America, are compared under the two heads of expedition and cost.

The three systems are (1) The push and pull method; (2) poling and ramming; (3) the "hump gravity" method.[1]

Figures of the time occupied and the cost of labour involved in the three systems are given for a typical case, with the result that the hump gravity system is found to be by far the most economical and expeditious. The figures given are based upon actual tests. The design and laying out of division terminal yards, having regard to the most important points requiring consideration, are next dealt with. Values of the gradients required for the satisfactory working of the hump gravity system to suit various classes of traffic are given, and diagrammatic sections of a number of hump gravity inclines from actual practice accompany the Paper. The dimensions of terminal classification yards, as based upon the traffic to be dealt with, receive consideration. The Author also discusses requirements in dealing with the separate classification of fast and local goods-trains, and the limit of size of classification yard which can be economically worked through a single-track throat. Diagrams are given showing the Author's views as to the most desirable form and lay-out of division terminal classification yards, tide-water terminal classifying yards and tide-water terminal goods-yards, and in each case the principal points to be kept in view in their design are enumerated. The elements of successful operation of any classification yard are also discussed.

In the discussion which took place upon this Paper, the Author stated that as a result of his experience the gravity hump yard presented advantages which could not be denied, whether the traffic was large or small. He gave figures as to the cost of

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[1] In the hump gravity method of switching cars, the track between the receiving and distribution division passes over a mound. The train is pushed up to the summit of the mound by a switch engine, and the cars being cut loose one or more at a time run down the other side by gravity and are switched on to the different distribution tracks. Usually there is a level track running alongside the hump track to connect the two divisions of the yard so that trains not to be switched need not be sent over the hump. Hump switching is supposed to have been first applied at Speldorf, in Germany, in 1876, and is now extensively used in Germany and France, where it is commonly known as the "ass-back" (*dos d'ane*) method of switching. In one of the yards of the Paris, Lyons and Mediterranean Railway the gradient of the hump is 1 per cent., and to balance the resistance due to the switches, curves, frogs, and guard rails, the turnouts are on a gradient of about ½ per cent. leaving the ladder, the remaining portion of the distribution tracks being level.—J. M. M.

handling wagons over the hump, and also a statement of the speed which had been attained in classifying with a given number of men. He remarked that the records taken since the hump was built on the line with which he was associated, showed that the damage to equipment directly chargeable to the hump grade amounted to only $800 (£167) in handling no less than 253,000 cars.

J. M. M.

Electric Traction on Main Lines. R. Bonin.

(La Revue Technique, 1904, pp. 15 and 80.)

The Author considers that for electric traction the maximum practicable pressure is 750 volts with continuous currents, while with alternating currents a pressure of 10,000 volts is not infrequent. The complications incident upon the employment of polyphase currents are pointed out, and two systems for using monophase currents are indicated; in the one, that of the Oerlikon Company, the high-tension alternating current operates a motor on the train, which in its turn drives a continuous-current generator, the current from which is distributed to the propelling motors; in the other, that of the Westinghouse Company, the same end is said to be attained without the intervention of the continuous current. The Author admits the advantages of quick starting and stopping in the case of suburban traffic, and agrees that electric traction is eminently fitted for attaining this result, because, from the fact that the current for each unit is only a small part of that sent out from the central station, a temporary overload can be supplied without difficulty, and also the adhesion is greater, owing to the greater number of axles which serve for driving. But he points out that, in present practice, steam-locomotives can get up speed remarkably quickly, figures being given to prove this; also that quick starts are not of vital importance on main lines. Undue weight seems to have been attached to the uniformity of the torque in the case of electric motors, as, with the four-cylinder compound steam-locomotives, the torque is almost as uniform. The coal-consumption in a steam-locomotive is put down at 2·90 lbs. per horse-power-hour, and that needed to produce a like result when burnt at a central station is given as 4·15 lbs. Occasionally the power can be obtained from waterfalls, but here again a large capital expenditure, coupled with costly maintenance, often makes the power so supplied by no means cheap. The question between the steam-locomotive and the electric is at present very like that between the original locomotives and the atmospheric railway, and the great inconvenience of a breakdown, either in the central station or in the conductors, is obvious, and would amount to a real danger in time of war.

If at some future time electricity can be stored economically on

the trains, or can be passed to them without the intervention of wires, this difficulty will be overcome. An additional disadvantage of electric propulsion on existing railways is the replacing of the rolling stock, which could not economically be converted to meet the new requirements. The Author is confident that electrification of main lines cannot but result in heavy loss.

I. C. B.

Tests with Electric Traction in Berlin. KURT MEYER.

(Zeitschrift des Vereines deutscher Ingenieure, 1903, p. 801.)

A few years ago the Prussian State Railway authorities fitted part of the Wansee Railway for electric traction, and ran electrically-propelled trains in the intervals of the ordinary steam-trains. After 2 years' continuous test the electric trains were suspended in 1902, the results having been satisfactory in every way except that they were unfavourable in regard to cost of running. It was decided to make new tests in more favourable circumstances on the railway from Potsdam to Gross Lichterfelde Ost, a length of about 9 kilometres ($5\frac{5}{8}$ miles). The mean distance apart of the stations was 1,800 metres ($1\frac{1}{8}$ mile). The power is obtained from the electricity works of the Union Company, which supply current for the Southern Tramways of Berlin. A 1,600-kilowatt machine supplies the working-current, but current may also be obtained from the other dynamos and a buffer battery. The trains consist of two third-class motor-carriages and one second-class motor carriage, the seating-capacity being 206 persons with the total weight of train 123 tons. The interval between trains is 20 minutes, except during the busy hours of the day, when a 10-minute service is provided. The average speed of the trains over the 9 kilometres is 32 kilometres (20 miles) per hour. This is the same speed as that of the steam-trains formerly in use, and was selected in order to obtain a comparison of the relative costs of working for steam and electricity. The Author remarks, however, that the value of such a comparison is questionable, as the greatest advantages of electric traction are the high speed and at the same time a rapid succession of trains and a make-up of trains suited to the traffic.

The pressure is 550 volts at the power-house, and the current is supplied to the motors by a third rail of soft iron weighing 82 lbs. per yard. The conductivity of the soft-iron rail is greater than that of the ordinary steel rail in the ratio of 8 to 5·3. The joining of these rails is effected by welding together three in succession, the joint for the next being made by fish-plates allowing of expansion, and flexible copper bonds.

The conductor-rail thus consists of alternate lengths of rigid rails 147 feet and 49 feet long. The Author gives detail drawings and descriptions of the conductor-rails, joints, feeder-junctions,

bonds, etc., sliding contacts, motors, etc. There are two 4-pole motors for each carriage, both on the same bogie. At 500 volts each motor can turn out useful work at the rate of 125 HP. for 1 hour with a temperature rise of 75° C., the current taken being 215 amperes. The Author goes very thoroughly and with great detail into the method of control. The working-currents pass through bars attached to the cores of solenoids, of which there may be a great number, according to the resistances to be cut out, whether there are one or two motors on each car, etc. These solenoids are energized by currents derived from the main leads by a shunt and passing through the controller contacts. These controlling currents of about 2 amperes are the only currents for which it is required to make provision to pass from carriage to carriage. The whole of a train can be controlled from any one carriage.

The Author finally gives the results of some trial runs, with diagrams showing speed, current, voltage, etc. The acceleration at starting was 0·5 metre (1·64 foot) per second per second.

J. G.

Trials on the Marienfelde-Zossen Electric Railway.[1]

(Elektrotechnische Zeitschrift, 1903, p. 1086.)

The article supplies further details regarding this railway, and is illustrated by a view of the Siemens car, showing the membranes and openings fixed to its front for measuring the wind-pressure, by details of the trolley-arm with its three sliding contacts, by views of the motor-truck and the track, by sketches of the connections, and details of the permanent way. The trolley-arm is specially constructed so as to avoid the sudden blows from the feed-wire, caused by the swaying of the car when travelling at high speeds. The track is provided with an auxiliary rail, formed of disused rails mounted horizontally on iron brackets, leaving a free space of 50 millimetres (2 inches) for the wheels, and preventing derailment. The rails weigh 41 kilograms (90 lbs.) per lineal foot, are 12 metres (40 feet) long, and are fixed to eighteen fir sleepers ballasted with basalt chippings. The total weight of the permanent way is 300 kilograms per metre (202 lbs. per lineal foot).

L. F. G.

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[1] Minutes of Proceedings Inst. C.E., vol. cxlix. p. 149; vol. clii. p. 398.

Working of Branch Railway Lines in Switzerland by Electric-Accumulator Cars. H. Spyri.

(Schweizerische Bauzeitung, vol. xlii., 1903, pp. 100 *et seq.*)

The Author discusses the difficulties which arise in attempting to make branch railway lines financially successful. Usually, they have very small passenger and goods traffic, and are worked at a loss. He has collected data regarding the cost of working such lines by means of a more frequent service of trains drawn by electric locomotives deriving their energy from secondary electric batteries charged at a central generating-station, and concludes that this is the best means of dealing with the problem.

He cites the results obtained at the Bologna-San Felice line, which only carried 180 passengers and about 40 goods packages daily, but since the change to battery-motors and the lowering of fares thereby rendered possible, the number of passengers has increased to 832, and a very large increase in the goods traffic has occurred. This has necessitated the employment of six trains daily in each direction, four for passengers and two for goods.

He goes most carefully into the working and traffic of the Uerikon-Bauma line, and appears to make out a very good case for the financial saving to be effected by the use of similar battery-motors upon the Swiss line.

E. R. D.

Electric Traction on the Railway between Saint-Georges de Commiers and La Mure.

(L'Electricien, 1904, p. 33.)

An explanation is given in this Paper of the circumstances which led to the trials of electric traction on the French railway between Saint-Georges de Commier and La Mure, and the system devised for the line by Mr. Thury is described in detail. The main feature of the system is that continuous currents are supplied direct to the line at high pressure. It is a three-wire system, the track serving as middle and neutral conductor, while two overhead wires form the outer conductors and have a difference of potential between them of 2,400 volts. The locomotive has four axles, each driven by a separate motor of 125 HP. taking current at 600 volts. Two of these are connected in series between one overhead conductor and the track, while the other two are in series between the track and the remaining overhead wire. The operation of this system requires a special form of controller, which is here described and illustrated, and a diagram of the electrical connections on the locomotive is given. The Paper

concludes with a specification of the traffic conditions, of the dimensions and weight of the locomotive, and of the main features of the electrical equipment.

W. C. H.

Single-Phase Electrical Traction and Speed Regulation

M. Latour.

(Elektrotechnische Zeitschrift, 1903, p. 1027.)

The Author mentions three types of motors with commutators, which may all be considered suitable for single-phase traction. These are (1) the repulsion motor with the stator winding in slots, (2) the shunt motor without phase-difference, which starts as a repulsion motor, and (3) the series motor without phase-difference. Type 2 may be suitably used for high-speed traction where uniform and constant speed is desired, but Types 1 and 3 are alone suitable for traction with varying speed. The repulsion motor has the advantage that it may be wound directly for high pressures, while the series motor is wound for low voltage, but the latter has in turn an advantage in that the magnetizing current required in starting is much smaller, and may be reduced to zero when the motor is run up to speed. Further, the series motor can be made lighter than the simple repulsion motor. Whichever type be adopted, if it is desired to work at various speeds, a suitable method of regulating the torque must be found. With a constant voltage supply the torque depends on the position of the brushes on the commutator relatively to that of the points at which the current enters and leaves the stator winding, and by a suitable adjustment the positive or negative torque for a particular speed can be obtained. Movement of the brush-holders, however, may involve mechanical complications in construction, so the desired result is preferably obtained in practice by changing the points of entrance and exit of the current to and from the stator. The Author describes and illustrates by diagrams the method by which he effects this.

W. C. H.

Single-Phase Alternating Current for Traction and Railway Service. B. G. Lamme.

(Electrical World and Engineer, N.Y., vol. xlii., 1903, p. 1043.)

The Author discusses at considerable length the different considerations, theoretical and practical, which have to be kept in mind in estimating the suitability for railway traction of the commutator type of single-phase motor, *i.e.*, having a commutator on the armature, and having the armature wound with a direct-current type of winding. This type of motor possesses

the characteristics of the direct-current railway motor. The field- or exciting-current is in series with the armature circuit, either directly or through transformer action, either in the motor itself or outside it. The former class is denoted by the name "straight-series motor," while the latter is said to be "of the transformer type." In such motors the two most important elements are the efficiency and the power-factor. Dealing first with efficiency, the Author considers each of the losses in the motor and compares it with the corresponding loss in the direct-current motor, and he concludes that, while no individual loss, except that due to the reversal of the magnetism in the field (which does not exist in the continuous-current motor), may be much greater than in the latter type, there are on the whole slight increases, and their sum total makes a difference of 1 per cent. to 5 per cent. in the efficiency of the motor. The frequency of the supply-circuit and the speed of the motor, with a given current and torque, also have an effect on the efficiency. With regard to the power-factor, the Author considers the different wattless components of the input of the straight-series motor, and compares this type with the transformer type, indicating various methods of improving the power-factor, and discussing in particular the use of resistance in series with the motor. He then passes to the question of commutation, in which the principal difficulty arises from the presence of local secondary currents in the coils short-circuited by the brushes, and thereafter notices briefly different methods of controlling the speed in motors of the types under discussion. Finally the Author refers to the existence of an active voltage between the field-turns, and shows how this affects the design of the motor.

W. C. H.

New Terminal Railway Station at Chicago.

(Engineering News, 6 August, 1903, p. 114.)

In this station the rails are elevated above the street-level in order to eliminate level crossings throughout the city. It is situated at the south side of Van Buren Street. About 186 trains per day use the station. The ground was excavated to a depth of 12 feet, and 50-foot piles were driven in rows and clusters for the foundation-walls and columns; they were cut off below the lake level, and upon them were built grillaged footings of steel I beams and concrete. The station buildings are 213 feet long by 157 feet broad and 185 feet high, and are of steel-frame construction. The main entrance to the ground-floor from Van Buren Street opens into a central hall 118 feet by 96 feet, adjacent to which are the ticket-office, baggage-checking rooms, refreshment-rooms, etc., with baggage-room and space for cabs and carriages behind; while staircases and elevators give access to the waiting-rooms and

platforms above. The upper storeys are railway offices. There are eleven lines of rails in the station with suitable platforms. The station-roof proper, 578 feet long, consists of nineteen pin-connected trusses, 207 feet span and 30 feet apart, with curved top and bottom chords; the depth at the centre is 25 feet, and each truss is divided into fourteen panels. The clear headway above the rails is 60 feet. Light is admitted by the glass sides of a monitor roof extending along the top, and through skylights in triangular projections from the roof, arranged so that the glass is at a considerable angle to the horizontal to facilitate keeping watertight. The ends of the roof are closed by glass screens. A complete power-plant is provided for the heating, ventilating, lighting, water-supply and elevator-service.

A. W. B.

Registering Appliance for the Rapid Inspection of Permanent Way. ROSSIGNOL.

(Revue générale des Chemins de fer, December, 1903, p. 331.)

The article describes an appliance used by the Northern Railway of France for some years to register quickly the condition of the permanent way. Its object is to enable an idea of the stability and regularity of a line to be formed with sufficient accuracy. In order to make the conditions comparable, the same saloon is always used coupled to the rear of the train, following a van specially used for this purpose, which is coupled tightly both with the train and the saloon, the interposition of the van tending to lessen the differences due to the influence of the train itself. The saloon has front and rear platforms and projecting windows in order to render the inspection of the line as easy as possible, and has a wheel-base of 18 feet 9 inches in order to secure great stability at speeds of 7[illegible] miles an hour and upwards.

The object of the appliance is to register the vertical movements, up and down, and the transverse movements, right and left. The longitudinal movements are not registered, on account of their being due mainly to the variations of the tractive force. The appliance is fixed in the centre of the saloon, and consists of "pendulums of inertia"; these pendulums are heavy and of short length, in order that they shall retake their position of equilibrium so quickly that superposition of two successive jolts is avoided. The displacements also are limited to one direction only, by means of fixed studs on the appliance, and in order to render the oscillations as short as possible, springs are attached, which can be adjusted. Two sets of pendulums are used, one set to register each kind of movement, the vertical movements being registered by pendulums oscillating on horizontal axes. The various oscillations are registered by a series of pencils, connected by levers with the pendulums, on bands of paper unrolling at a

constant speed, upon which the mile-posts and all other special points, such as junctions, tunnels, stops, &c., are marked; the exact speed of the train is therefore noted between the mile-posts, and the point where a jolt has been registered, and it is also seen at once whether the jolt has occurred at any particular point of the line.

The Author claims that by the use of this appliance the admissible limits of movements on any line can be found; that when these are shown by the graphical tables to be exceeded there is some defect on the line to which attention can be drawn at once, and the line tested again to see if the defect has been repaired. He also states that the Northern Company have derived very appreciable advantages from its use.

The Paper contains plan and sections of the appliance.

J. A. T.

Train-lighting by Electricity in Switzerland.

(Schweizerische Bauzeitung, vol. xlii. 1903, p. 135.)

For some time past the Vicarino system of train-lighting by electricity has been used experimentally upon certain carriages on the Swiss Government Railways. The apparatus was made by the Alioth Company of Münchenstein-Basel, and consists of a dynamo of special construction, belt-driven off the axle of the coach, with one or more secondary batteries and a controlling gear which regulates the voltage and switches the battery in or out of circuit. The dynamo is designed to permit of very varying speeds, and a special brush-carrier with counterbalance-weight moves the brush through an angle of 180° as soon as the dynamo begins to run in the reverse direction, so that the polarity of the terminals of the dynamo remains constant. The special feature of the Vicarino system appears to be the pressure-regulator; this seems to be effective, as a sheet from a recording voltmeter is reproduced in the original, showing that the fluctuation in pressure never exceeded 0·5 volt, the lowest reading being 17·1 volts and the highest 17·6 volts during 3½ hours.

The dynamo is compound wound, the series coil being in opposition to the shunt. At starting the dynamo runs as a shunt machine on open circuit, and continues so until a speed of 600 revolutions per minute is attained with a pressure slightly in excess of that of the battery; then it is switched automatically on to the battery, and at the same time a compensating resistance is switched into the lamp-circuit. As a rule two batteries are employed. The chief feature of interest is the automatic switch, which is illustrated in section in the original, and consists of a solenoid with first a winding of thin wire and then a winding of thick wire on the outside. The core goes right through the bobbin

and has a contact-maker at each end; these are not rubbing contacts however, and so may possibly give trouble by sparking. With two batteries a special switch is used, which alternately puts each battery into circuit for charging by the mere action of switching the lamps on or off. The weight of the dynamo is stated to be only about 200 lbs.

E. R. D.

Heating of Railway Carriages by Steam and Compressed Air Combined. LANCRENON.

(Revue générale des Chemins de fer, November, 1903, p. 323.)

The administration of the Eastern Railway of France has recently approved of the application to nearly all their trains of appliances for heating by steam and compressed air combined. The tests have extended over a period of 10 years, the results of the first tests and a general description of the appliances having been given in a previous Paper.[1] The Author claims that the addition of air to the steam causes a continual movement of the condensed steam, prevents accumulation of water at the low points of the conduit, and enables long trains to be readily and uniformly heated from end to end. The tests made in the coldest weather with trains consisting of from sixteen to thirty vehicles were satisfactory, and are described in detail; the results showing that a long train can be easily heated by this system when it would be impracticable if steam alone were used.

The appliances consist of a general conduit from end to end of the train, with branches of heating tubes, generally three in number, under the floor of each compartment. Either one, two, or three tubes are used, according to the exterior temperature. In the first- and second-class compartments the passenger can manipulate the levers controlling the passage of the mixture of air and steam into the tubes, but in the third-class carriages the control is from the outside only. When the fitting up of the trains and engines is completed there will be a total of 756 engines and 4,487 carriages provided with the system at a cost of £184,000, being at the rate of about £50 per engine and £35 to £40 per carriage. Plans and sections of the appliances together with detailed descriptions are given in the Paper.

J. A. T.

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[1] Minutes of Proceedings Inst. C.E., vol. cxxi. p. 383.

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tons) each, or four axles with a load of 18 metric tons (17·716 British tons). The distance between centres of any two axles being assumed to be 1·5 metre (4 feet 11 inches).

The wind-pressure allowed for is to be 150 kilograms per square metre (30·7 lbs. per square foot) with the bridge loaded, or 250 kilograms per square metre (51·2 lbs. per square foot) with the bridge not loaded. The actual surface of the bridge exposed to such pressure is to be determined from the actual dimensions. The surface of a train is to be taken as a rectangle, having a height of 3 metres (9 feet 10 inches) above rail-level. If the bridge is on a curve allowance is to be made for centrifugal force. The centre of gravity of the vehicles is assumed to be 1·5 metre (4 feet 11 inches) above rail-level.

If the bridge is on a gradient or just before a station, it may be necessary to consider the effect of braking. The calculation of temperature-stresses is to be based upon a variation of temperature between $-25°$ C. and $+45°$ C. ($-13°$ Fahr. and $+113°$ Fahr.). If the material used is mild steel (ingot-iron) the permissible tensile stresses upon members of compound girders (counterbracing excepted) or flanges of plate-girders of more than 10 metres (32 feet 10 inches) span are to be—

20 Metres Span, (65 Ft. 7 In.).	40 Metres Span, (131 Ft. 3 In.)	200 Metres Span, (656 Ft. 2 In.)
1,000 kg. per sq. cm. (14,223 lbs. per sq. in.)	1,050 kg. per sq. cm. (14,934 lbs. per sq. in.)	1,250 kg. per sq. cm. (17,779 lbs. per sq. in.)

In spans of intermediate dimensions the permissible stress varies directly as the span.

If wrought iron is used, the permissible stresses are to be taken 10 per cent. lower than the above values. Stresses are, as a rule, to be calculated with wind-pressure taken into account. If wind-pressure is not taken into account, figures are given for lower stresses.

For compression-members the same limits of stress are to be taken as for tension-members, but there must be, in every case, a factor of safety of 5 against buckling when using Euler's formula.

For small spans, not exceeding 10 metres (32 feet 10 inches), the limit of stress is fixed at 800 kilograms per square centimetre (11,378 lbs. per square inch) for mild steel, and 750 kilograms per square centimetre (16,667 lbs. per square inch) for wrought iron.

If the line is ballasted the stress in cross girders may be the same as in main girders. When the rails are fixed to transverse sleepers resting directly on longitudinals, lower stresses are to be allowed, and figures are given for these conditions.

The subjects of wind-bracing and permissible stress upon rivets receive attention. The permissible stress upon rivets is fixed at lower figures than are allowed for tension-members.

Under the head of calculation it is stated that, as a rule, it will not be necessary to take into consideration the secondary stresses arising from rigidity of joints.

The maximum bending moments produced in bridges resting upon two supports, and subjected to the loads previously described, are to be taken from two tables which are embodied in the rules. These tables give the maximum moments in tonne-mètres for all spans, from 1 metre (3·28) feet) to 150 metres (492 feet). The curve of maximum moments is taken to be compounded of two parabolic curves, connected by a horizontal straight line over the centre of the span and having a length of 0·12 of the span. The calculation of the maximum moments at points other than the centre of the span is facilitated by a table giving the ratio of the moment at the given point to the moment at the centre of the span.

The maximum shearing stresses produced by the live loads, previously described, are to be calculated with the assistance of a third table giving the sum of all loads upon any span, and also the sum of the moments of those loads around the centre of the last axle of the advancing train.

J. M. M.

New System of Traction for Coupled Wagons on Highways.

C. Renard.

(Comptes Rendus, vol. cxxxvii., 1903, p. 1234.)

This Paper gives an outline, without details, of a system of traction for a train of wagons or other vehicles on highways, whereby power is transmitted mechanically from a light locomotive or motor-car to each vehicle in the train, so that all the wheels are driving-wheels. The motor drives a shaft which runs the whole length of the train and has a flexible coupling between each pair of wagons. The details of the transmission are not given. In addition to the coupling for power-transmission, the Author provides a "directional coupling" to ensure that each unit in the train will follow the same path as the leader in going round curves. From a mathematical analysis he concludes that to obtain this result the parts of this coupling must have the following relations:—If a be the length of the wheel-base of any wagon, b, the length of the link from the middle of the front axle to the coupling, and c, the length of the link from the coupling to the middle of the rear axle of the wagon immediately in front, then

$$c^2 = a^2 + b^2.$$

The description of the main feature of the system, the elastic coupling for power-transmission, is reserved. The Author states that the system has already been tried with success.

W. C. H.

Vernaison Suspension Bridge.

(Nouvelles Annales de la Construction, Nov., 1903, p. 1616.)

A suspension bridge has recently been constructed over the Rhone at Vernaison, near Lyons. The total length of bridge over extremities of abutments is 360·72 metres (1,183 feet), the three spans being 52·5 metres (172 feet), 232·82 metres (764 feet), and 42·4 metres (139 feet). The width between centres of hand-rail fences is 5·12 metres (16·8 feet), or sufficient for the passage of two vehicles abreast. There are no footpaths. The superstructure is of steel, excepting only the deck of the roadway which is of wood.

The foundations of the two piers were sunk by compressed air to a depth of 6 metres (19·7 feet) below low-water mark, and the piers are about 31 metres (101 feet 8 inches) high above the same datum. They are of concrete faced with freestone, the pier on the right bank being 22·34 metres (73·2 feet), and that on the left bank 20·21 metres (66·3 feet) above the level of the bridge platform. This difference in height arises from the navigation requirements, the navigable channel being nearer to the right bank. Each pier consists of two rectangular obelisks of about 2·68 by 4·15 metres (8·8 feet by 13·6 feet) at the base by 2·4 by 1·8 metres (7·88 feet by 5·91 feet) at the summit. The obelisks are bound together by two cross walls of masonry. The space between the cross walls is occupied by a ladder for giving access to the top of the pier.

The anchorages are of masonry 10 metres (32·8 feet) wide by 17 metres (55·8 feet) long by 7·5 metres (24·6 feet) deep from road level to low-water mark, where they rest upon a bed of concrete 0·30 metre (11·81 inches) thick. Horizontal and inclined passageways are provided in the masonry to facilitate inspection and renewal of the iron and steel work.

The cables of steel wire-rope are in two groups of twelve, one group on each side of the bridge. The steel wire developed an ultimate strength of 140 kilograms per square millimetre (88·9 tons per square inch). The cables are continuous from anchorage to anchorage, and are carried over the pier-heads on a rolling carriage. The whole of the anchorage attachments are so arranged that each rope is entirely independent of the others, and can, if required, be removed and replaced easily. On each side of the pier for about 31 metres (102 feet) from the face of the masonry, the platform of the bridge is carried by oblique stays attached at their upper ends to the rolling carriage on the pier-head, and at their lower ends to a longitudinal stringer beam of I section 300 millimetres by 145 millimetres by 11 millimetres (11·8 inches by 5·7 inches by 0·43 inch) placed outside the hand-rail fence, and connected to the cross girders.

The cross girders of the remainder of the platform are carried by vertical suspenders of round bars 34 millimetres (1·34 inches)

diameter. Reverse diagonal stays, two in number, at each side of each pier, run up from the feet of the piers to points on the cables about 28 metres (91·8 feet) from the centre of the piers. The cross girders are of steel, with plate webs and angles. They are 1·25 metres (4·1 feet) apart from centre to centre, and are of varying depth, for lightness, and to provide convexity for the roadway. The depth over angle-bar flanges at the centre of the roadway is 0·35 metre (13·78 inches), and at the ends 0·2 metre (7·88 inches). The length is 6·00 metres (19·68 feet) for cross girders carrying stays to hand-rail fence and 5·70 metres (18·7 feet) for intermediates.

The hand-rail fences are continuous lattice girders 1·20 metres (3·94 feet) deep over the flanges. They are counted upon to resist inequality of moments produced by rolling loads, and also act as the booms of the lateral wind-bracing. The vertical and diagonal web members are articulated at their ends. The verticals are 1·25 metres (4·1 feet) apart, and coincide with the cross girders. The diagonals have screw adjustments at their upper ends. The horizontal (lateral) bracing of the platform consists of a double system of diagonal steel bars. The decking is carried upon sixteen oak joists, 260 millimetres by 100 millimetres (10·24 inches by 3·94 inches), laid flat, to which is spiked pine cross planking 60 millimetres (2·36 inches) thick. The clear width of road of 4·62 metres (15·15 feet) is bounded by oak curbs, 250 by 140 millimetres (9·85 inches by 5·51 inches). The erection of the bridge followed the usual lines adopted in such structures. The principal feature of the structure in detail design is the attempt made to provide a superstructure of which any part can be removed and renewed without disturbing the remainder or stopping the traffic.

The bridge was tested both by dead loads and rolling loads. The three spans were tested separately by a uniformly distributed load of 200 kilograms per square metre (41 lbs. per square foot). The entire bridge was then subjected to the same load. The maximum deflection measured at the middle of the central span under the most unfavourable condition, *i.e.*, when that span alone was loaded, was 494 millimetres (1·62 feet), and during this test the rolling carriages on the tops of piers were displaced 32 millimetres (1·26 inches) and 34 millimetres (1·34 inches) respectively. Tests were also made with rolling loads of two vehicles with single axles (two wheels), and each weighing 8,000 kilos (7·87 tons) and proceeding from opposite ends. Each vehicle was drawn by five horses in single file, and when passing each other at the centre of the bridge, they caused a deflection of 326 millimetres (1·07 foot). A second test made with one four-wheel vehicle, weighing 11,000 kilograms (10·82 tons), drawn by nine horses in single file, caused a deflection of 329 millimetres (1·08 foot) at the middle of the central span. These moving loads caused merely feeble tremors without rhythmic oscillation, and in common with the dead-load tests produced no ill effects in masonry, cables, or platform.

The cost of the structure was approximately as follows:—

Masonry.	180,000 francs	(£7,150)
Superstructure	345,000 „	(£1,3700)

The total weight of the steel and iron was 416,000 kilograms (394 tons).

The article is accompanied by one figure in the text and by two plates, showing general dimensions and details.

J. M. M.

Reconstruction of the Frans Bridge at Villefranche.

(Le Génie Civil, vol. 43, 1903, p. 417.)

The suspension bridge of 161 metres (528 feet) span, which connected the town of Villefranche with the left bank of the Saone, having been found insufficient for the traffic, it was decided to reconstruct it, in order to take two lines of railway in addition to the ordinary traffic.

Owing to the necessity of keeping the bridge in the same position, and in the absence of definite particulars regarding the foundations of the central pier, it was decided to make the new bridge in three spans, and to build two new piers. The type of bridge chosen was the cantilever with a central junction girder, the central span being 70 metres (229 feet). The piers were constructed by sinking caissons 4·5 metres (14·75 feet) in diameter, the total weight of each pier when completed being 411 tons.

The main spans were erected as follows:—A floating pontoon with staging above was moored to the river bank, and a span was built upon this staging and the shore; the shore-end being carried on rollers, and the river-end projecting over the staging. When completed the pontoon was gradually moved out to the pier, and when the projecting end of the span overhung the pier, the pontoon was lowered in the water until the girders rested on the pier. The river ends were then built out simultaneously, and the connecting girder placed in position.

Full details of the construction and testing of the bridge are given, the total cost of which was £23,000.

The Paper is illustrated by three figures in the text, and one plate of detail drawings.

H. I. J.

Novel Type of Drawbridge.

(Engineering News, 22 October, 1903, p. 372.)

In arranging for electric towage on the Miami and Erie Canal[1] the Transportation Company of Cincinnati use trolley locomotives

[1] Minutes of Proceedings Inst. C.E., vol. clv. p. 461.

on a track along the towing path, which crosses the canal at several places. In order to make the curves as easy as possible, the crossing is made by a skew bridge, which of course must be moved out of the way to allow boats to pass. To render these inexpensive, the type of bridge adopted is pivoted at one end, the other end being provided beneath with a frame supported on rollers running on a curved rail in the bed of the canal. The example illustrated is a deck plate-girder bridge of 64 feet span, with piled approaches and pivot pier. It has a swing of 30°, and the width of the canal is about 45 feet, which is reduced to 22 feet between the timber protection works. The heels of the girders are connected by a semicircular drum girder, and two 15-inch I beams are fitted to carry the centre bearing. At the outer end of each girder is a post composed of four 5-inch by 3-inch Z bars, which are connected at the foot by 10-inch steel channels; the foot of each post has a shoe in which is pivoted a 12-inch roller turned to a conical face, which rides on a 70-lb. curved steel rail. On the outside of this is a segmental rack, and both are bolted to a steel plate on the caps of piles driven into the bed of the canal. An electric motor mounted on the bridge drives a pinion which gears with the rack. A bolt at this end of this bridge, pressed outward by an elliptical spring, holds the bridge in position until withdrawn by magnetic power. The electric motor also drives a small centrifugal pump supplying 1-inch jets for washing mud and silt from the rack and roller path. The motor and bolt magnet are operated by switches on the shore, so placed that the motorman on the electric locomotive can work them from his cab after crossing the bridge, and this allows the boats he is hauling to pass.

A. W. B.

Concrete Bridge over the Big Muddy River, Illinois Central Railway.

(Engineering News, 12 November, 1903, p. 423.)

The Illinois Central Railway crosses the Big Muddy River, a stream draining a large section of southern Illinois, and discharging into the Mississippi River a few miles below Grand Tower. In doubling this portion of the line the railway company has built a concrete structure to take the place of the original three-span single-line Pratt-truss bridge. The new bridge has three elliptical arches, each of 140 feet clear span and 30 feet rise above the springing-lines. Its construction occupied 20 months, during which time the regular traffic of the road was maintained. The Pratt-truss spans rested on masonry piers and abutments supported on pile foundations; the spans were 161 feet centre to centre of piers. The pile foundations, as well as the footing courses of the piers, had been put in of the full width needed for

double lines; the upper parts of the piers, however, were only long enough for a single line of rails.

The masonry was generally in sound condition, except that the north abutment had cracked and settled a little. It was decided to drive additional piles round the old foundations, and to place the base of the added masonry at a lower level than that of the old piers by 4 feet to 13 feet. Advantage was taken to raise the height of the bridge and so take a sag out of the line. It was decided to make the piers for the arches 21 feet 6 inches at the springing. The arches were made true ellipses, the net thickness at the crown being 5 feet, and it increases towards the haunches. To reduce the weight on the foundations, the spandrels are composed of small arches, instead of filling in with earth between heavy walls. The main ribs were built as a series of voussoirs in such order as to keep as symmetrical a load as possible on the wooden centering. The spandrels contain an internal braced steel structure to reinforce the concrete, but the voussoirs were simply recessed into each other.

A. W. B.

Movable Cylindrical Weirs. D. Bellet.

(La Nature, Jan. 23, 1904, p. 119.)

Attention is directed to the increasing importance which is attached to the use of weirs, partly in regulating the course of rivers, and partly with a view of obtaining hydraulic power for electric installations. It is often deemed necessary to arrange for the partial or gradual suppression of the weir during floods, in order to give free discharge to the superabundant water, and consequently various plans have been devised for throwing down the weir or temporarily lowering it in sections. Mention is made of the curtain-system for weirs invented by Mr. Caméré, and of certain difficulties in keeping the sill of this weir free from sand and silt. A novel system, designed by Mr. René Kœchlin, in use at Mulhausen on the Rhine is then described and illustrated. This weir, which holds up 9·8 feet of water, has a total width of 590·5 feet, and is in the form of a series of cylinders 9·8 feet in diameter made of wrought iron, 0·59 inch in thickness. Each span of the weir is upwards of 85·3 feet in length, and the ends of the cylinders are fixed in vertical chases prepared for them in the piers. These cylinders rest on plain flat sills sunk in the bed of the river. Winches and winding-gear are provided at each end on the tops of the piers, by which the cylinders can be raised or lowered at will. The total weight of each cylinder is about 45 tons, and by means of the electric winches it can be raised or sunk in about 10 minutes. The cylinders are open at the ends, so that the water has free access. In lieu of using a single large cylinder,

t is of course easy to employ two or more smaller cylinders, placed one above the other. This form of weir is said to present a high resistance, to be very rigid and to be quite free from silting-up. By means of an illustration an account is given of a cylindrical weir at Schweinfurth, which, in lieu of being raised vertically, is furnished with rack-gearing and made to travel upwards in a chase inclined at an angle of 45°. Powerful winding-gear is provided at each end for raising and lowering the cylinder, which is 13·1 feet in diameter and 59·04 feet in length, while another in course of construction is 6·5 feet in diameter and 114·8 feet in length.

G. R. R.

Towing Raft-Timber on the Canalized Moldau. K. Ebner.

(Zeitschrift des oesterreichischen Ingenieur- und Architekten-Vereines, 1903, p. 595 *et seq.*)

Owing to the projected extension of the canalization of the Moldau as far as Budweis, the Author was commissioned to experiment on the towing of raft-timber down that stream, the reduced velocity of the current, in consequence of the construction of locks, having retarded the transport by ordinary flotation. Two steamers, of 114 I.HP. and 180 I.HP. respectively, were employed for towing, and the tractive force was determined by means of a Richard dynamometer, fitted with a pair of hydraulic registering instruments connected with the dynamometer by flexible but inexpansible tubing. Comparative trials were also made with barges, and the results show that, while little advantàge is to be obtained by towing the timber in rafts, the use of 300-ton barges works out only 5 per cent. dearer than free flotation; and that, on the other hand, there is a saving of 22 per cent. in the time of transport, owing to the avoidance of the delay in dismounting the rafts for shooting the weirs.

A description is also given of the Schwarzenberg canal for the flotation of timber from the Lichtwasser brook in the Böhmerwald to the Mühlfluss river, running into the Danube. This canal is 51·8 kilometres (32 miles) in length, and was constructed in two portions, the first in 1788, and the rest in 1822. The total fall is 420·9 metres (1,381 feet), and the highest gradient is 18 per cent., the lowest being 0·17 per cent. The canal is partly through cuttings and partly embanked, there being also an aqueduct, 70 metres (230 feet) in length, and a tunnel 419·1 metres (1,370 feet) long. The sectional dimensions are as follows: width at crown 2·5 to 2·8 metres (8·2 to 9·2 feet), width at bed 2 to 2·2 metres (6·5 to 7·2 feet), and depth 1 to 1·2 metre (3·28 to 3·9 feet). The sides are for the most part lined with quarried stone or granite sets. Until recently the sharp curves in many parts of the course precluded the floating of trunks, but, as the timber was chiefly used for fuel, this presented no drawback, the trunks being cut into

logs before entering the canal. Owing to the increased demand for long timber, the curves in the upper section (22·6 kilometres = 14 miles) have had to be modified, and now trunks 23 metres (75 feet) long can be floated as far as the Hefenkrieg brook. Here there is a newly constructed branch flume, 3·8 kilometres ($2\frac{1}{4}$ miles) in length, and with a total fall of 115·4 metres (378 feet), leading into the Moldau at Salnau, where there is a steam sawmill. At first this flume was lined with round timbers, but these have now been replaced by masonry. The maintenance of the necessary depth of water in the canal to float log timber entails a supply of 695 litres (153 gallons) per second, which in the highest gradients must be increased to 1,768 litres (389 gallons); and this is secured by drawing on the twenty-seven brooks crossed, and also on the two lakes in the vicinity.

C. S.

Electric Towing on the Teltow Canal.

(Elektrotechnische Zeitschrift, 1903, p. 1083.)

The towing is done by a locomotive taking current from an overhead wire, or a motor-boat. The locomotive is provided with a windlass, and a high extensible mast, to which the tow-line is fixed. The windlass consists of a drum on to which the rope is wound by an electric motor. The drum is not rigidly coupled to the motor, but connected to it by friction-wheels which begin to slip when the pull in the rope exceeds 1,500 kilograms (3,300 lbs.). If by accident the towline becomes entangled, an automatic arrangement releases it from the drum. When starting with a heavy load, the rope gradually slips off the drum owing to the increased pull, but when full speed has been attained it is again wound up by the motor. A load of 1,450 metric tons (1,425 tons) was towed at an average speed of 4·35 kilometres (2·7 miles) per hour, the starting pull being 2,000 kilograms (4,400 lbs.), and the average pull while towing, 1,000 kilograms (2,200 lbs.). The current used was 35 amperes at 545 volts, giving a mean efficiency of 61·5 per cent. At another trial, the load was 1,250 metric tons (1,230 tons), the pull 900 kilograms (1,980 lbs.), and the velocity attained 4·3 kilometres (2·67 miles) per hour; the voltage being 525 volts, and the current 31 amperes, indicating an efficiency of 65·5 per cent. At 5 kilometres (3·1 miles) per hour and 595 volts, 33 amperes were used, the load being 1,000 metric tons (984 tons) and the pull 950 kilograms (2,090 lbs.), giving an efficiency of 66 per cent.

The motor-boat is 18 metres (59 feet) long, 3·8 metres (12·5 feet) broad, with a draught of 1·43 metre (4·7 feet). It carries 220 accumulators, a 20-HP. motor working at 600 revolutions per minute, and is fitted with three screws. The current can also be taken from an overhead wire. When towing a load of 454 metric tons (446 tons) the velocity was 5·2 kilometres (3·23 miles) per

. ·· energy required 43 kilowatts. The efficiency when the boat is therefore less than when using the loco- › being due to the inefficient working of the small ·he boat.

L. F. G.

... ctric Installation for Draining the Donge Polders.

W. G. C. Gelinck.

(... hrift van het Koninklijk Instituut van Ingenieurs, 1903–1904, p. 59.)

' ... Donge polders are part of a larger area inundated in 1421, ... situated south of the River Maas. For centuries the submerged ... remained uninhabited, till, in the seventeenth century, they ...rped up sufficiently to be embanked, but in a very haphazard ..., every owner working for himself without much regard to the ...blic interest. The whole district was divided off into islands of ...fferent sizes and levels. In dry summers these lands gave ·xcellent hay crops and grazing, but in winter and wet seasons all ...as flooded. As, moreover, these small, low-lying polders were ...ivided from one another by numerous creeks, streams and water-channels, carrying off the drainage from the higher grounds, a plan for bringing all the thirty-four polders under one general system could hardly be thought of. To furnish a complete and separate drainage engine to each of the comparatively small enclosures was financially impracticable. This led to the idea of furnishing the motive-power from one central installation to the different pumps or turbines. This central electric station was placed near the railway, for the convenience of the supply of fuel and materials. It is connected with the thirty-two small drainage-engines by copper overhead wires. These engines, all of one type, but of different sizes, consist of a Neukirch horizontal turbine sheltered in a simple cabin. The two generators at the central station are driven by a steam-engine of about 50 HP. and at 400 revolutions per minute supply 100 kilowatts at 3,000 volts. The contracts were let in July, 1900, and the work was finished in 1902, at a cost of about £40,000. The Paper is illustrated with plans and drawings.

H. S.

Electric Capstans at the Port of Antwerp. Solier.

(L'Éclairage Électrique, vol. xxxviii., 1904, p. 94.)

This paper gives a description of the electric capstans designed by Messrs. Dufour and Thury for use on the quays at Antwerp, where they are employed in bringing wagons from behind the sheds on to the quays. There are in all twenty-seven capstans in use, each driven by a series motor of uniform type and all the motors con-

nected in series in the distributing circuit. The principle underlying their operation is as follows:—If the motor-brushes are placed in the axis of the field-poles, the current will not start the motor; but if the brushes are displaced from this line, there will be a torque producing rotation, and for a certain position of the brushes this torque will be a maximum. Thus the power of the capstan is directly proportional to the angle of lag of the brushes, while the speed of the motor depends on the external load. All that is necessary for the starting and control of the capstans, therefore, is a pedal connected mechanically to the brush-holder. When the attendant presses this pedal, he moves a lever which shifts the brushes from the neutral line to the position of maximum torque. This lever is balanced by a counter-weight, and one of its arms is connected to a switch, which short-circuits the motor when that arm is in its upper position, that is, the position it occupies when the pedal is free. Thus when the attendant releases the pedal, the counter-weight at once returns the lever to its initial position, and in so doing operates the switch, so that the motor is short-circuited. In order to prevent the attendant from pressing the pedal too strongly, resistance to pressure is provided by a piston in a cylinder of oil, but this resistance does not act against the counter-weight. As the running of the capstan must be stopped as nearly instantaneously as possible, the normal position of the motor-brushes is fixed a little to one side of the neutral line in the opposite direction to that of the rotation of the motor, so that when the pedal is released the running armature is subjected to a force tending to rotation in the opposite direction, and the motion is very quickly stopped. An arrangement is also provided for automatically short-circuiting the motor if the speed should suddenly become too high from any cause. The motors are designed to take 100 amperes at 150 volts, and to develop 18 HP. at 450 revolutions. On the axle of each motor a pinion is mounted which drives a toothed wheel connected directly to the drum.

In the main circuit the motors are in series, but the number in use at one time may vary greatly, and it is therefore necessary to provide for a constant current in a circuit of variable resistance. That is, the pressure supplied by the generator must be variable, and the Paper gives an outline of the proposed method for effecting this result. W. C. H.

The New Lighthouses of the Argentine Republic.

L. Luiggi, M. Inst. C.E.

(Memoria presentada al Segundo Congreso Cientifico Latino Americano celebrado en Montevideo.)

After describing the advantages procured by lighthouses generally the Author says he was invited by the Argentine Authorities to prepare a complete scheme of lighthouses for their coasts, all

of them to be connected with the telegraph wires and furnished with meteorological instruments. Alluding to Lord Kelvin's plea for more rapid delivery of characteristics in lighthouses he states that, thanks to the lightning-light system, it had become possible to carry out such a scheme from Mogotes Point to Isla de los Estados at moderate cost. In illustration of the economy of that system the Author mentions his having put up in 1885 the Hopkinson group-flashing electric light at Tino at a cost of £6,000 for optic, lantern, machinery and accessories alone, whereas it had become possible in 1900 to erect an incandescent-mantle lightning-light as powerful as the Tino light at a cost of £2,400, the maintenance of which would only amount to one-third as much as at Tino.

The Author's scheme includes twelve third-order lightning-lights, namely, three 1-flash lights of 5 seconds period, four 2-flash, three 3-flash and two 4-flash lights, all of 10 seconds period. Lights of one character are kept at least 400 miles apart. The duration of flash is in all cases $\frac{1}{10}$ second. In addition, there are two small occulting and two fixed lights. Reasons are given for the choice of site in the case of each lighthouse. On account of their relative simplicity oil-burners have in general been preferred, incandescent burners only for two lights at the entrance to Bahia Blanca. The six lights most urgently required for Bahia Blanca, Rio Negro, Rio Chubut, Isla Penguin and Isla Año Nuevo, were obtained by contract from Messrs. Barbier and Bénard, through the Argentine Legation in London advised by Mr. Douglass, for about £16,000. They were expected to be lighted in 1902. The complete scheme of illumination, inclusive of old lights, comprises twenty-six lighthouses and thirty-three buoys, mostly gas-lighted, the latter in Rio de la Plata and Bahia Blanca. The Author, in conclusion, expresses a hope that a dark zone on the Uruguay side of the estuary of La Plata will soon be lighted. The memoir contains a small map on which the lights are marked.

A. Br.

Lighthouse of Ferro-Concrete.

(Le Génie Civil, vol. xliv., 1904, p. 108.)

A lighthouse of ferro-concrete has just been constructed at Nicolaieff, near Odessa. The height is 131 feet, the diameter at the base 28 feet, and that at the top of the shaft 6 feet 7 inches. The service room, which is 14 feet 3 inches in diameter, is corbelled out, and thus overhangs 3 feet 10 inches on each side of the tower. For purposes of design the tower was considered as a tube firmly fixed at one end, and acted upon by a distributed pressure, due to wind, of 56·4 lbs. per square foot. The foundation is sunk only 8 feet 3 inches below the surface of the ground. The skeleton consists generally of upright rods and of circular rings,

the surrounding concrete being composed of 660 lbs. of Portland cement, 1 cubic yard of ballast and ½ cubic yard of sharp sand. In order to ensure that the concrete takes a firm hold of the framework, the latter is brushed over with grout prior to the concrete being run in. It is claimed that a saving of 40 per cent. is effected by the use of the ferro-concrete. The weight of the structure is given as 453 tons, of which 342 tons only represent the weight of the ferro-concrete, whereas the weight of such a lighthouse put up in the ordinary way would be 1,343 tons.

I. C. B.

The New Electric Quick-flashing Light on Heligoland.

O. Arendt.

(Helios, 25 November, 1903.)

The Author claims that this light, inaugurated in June, 1902, is the most powerful to be found in any lighthouse, besides being without precedent optically and mechanically. Although foreign experts were sceptical, it has been a great success. The optic consists of three polished glass parabolic mirrors, backs converging inwards with axes 120° apart horizontally, each having at its focus a continuous-current arc-lamp. As they revolve once in 15 seconds, a flash of $\frac{1}{10}$ second recurs every 5 seconds all round the horizon. Partly as a standby, and partly for testing the efficacy of still shorter flashes, a fourth similar projector is mounted above the other three and arranged to revolve once in 5 seconds, giving a flash of $\frac{1}{30}$ second every 5 seconds.

The three projectors placed on one table revolve upon a common ring of steel balls, but the weight is borne mainly by a mercury float turning in a fixed annular bath. Down the central hollow of this bath and connected to the main turn-table a tube descends, through which six electric cables rise. One brings current to each arc-lamp, one to the upper electro-motor, and one serves as a common return-cable. The tube ends below in a small turn-table surrounded by a toothed ring and running on a small ring of balls, which roll on a fixed base-plate. The latter carries five circular mercury troughs concentric with a central one. The six cables penetrate the lower turn-table, each ending in a knife which dips into one of the troughs. A small electro-motor underneath acting through a worm-wheel and pinion of raw hide, drives round the small and the main turn-tables. A similar arrangement serves for the rotation of the uppermost turn-table. The current is brought through a lead-covered cable of 100 square millimetres (0·15 square inch) from the engine-room, distant 200 metres (218 yards), where there are two steam-dynamos for 216 amperes, and 65 to 75 volts. The work was executed by the Elektrizitäts Aktien-Gesellschaft, of Nuremberg.

Photometric tests with a Weber photometer, at a distance of 1,290 metres (1,406 yards) showed that the light from one projector of 255 millimetres (10 inches) focal distance and 755 millimetres (29·7 inches) diameter had a maximum power of 42·7 million and a mean power of 39·53 million candles. For a current of 34 amperes the crater of the positive carbon has a diameter of 9·7 millimetres (about $\frac{3}{8}$ inch).

The geographic range of the lighthouse is 23 nautical miles, but on the first night it was clearly seen at a distance of 34½ miles. The Paper is illustrated by a vertical elevation and section of the apparatus, a general view of tower and buildings, and a view showing the appearance the lighthouse presents at night.

A. Br.

Fresnel Catadioptric Profiles with Curved Refracting Sides.

WALTER KÖRTE.

(IX. Internationaler Schiff-fahrte-Congress, Düsseldorf, 1902. Part II. of Communication No. 4 of Section II.)

Catadioptric rings of the usual form cannot be made so accurately as dioptric rings, first, because it is difficult to place the straight refracting sides of the profile accurately relatively to each other and to the reflecting sides; and, secondly, because the radius of curvature of the reflecting side increases so rapidly with increase of focal distance that it becomes impossible to work from the proper cutting centre. Mr. Wilhelm Weulle, proprietor of glassworks in Goslar, Harz, asked the Author whether it would be possible to substitute curved refracting sides for the usual pair of straight sides in such profiles, and thus get rid of the difficulties connected with the latter. The result of the Author's investigation has been that this might be done, and that the adoption of such curved refracting sides would at the same time provide a means of removing the other difficulty arising from excessively long radii for the reflecting sides. The investigation was completed theoretically late in 1900, and has since been practically verified. The Author discusses mathematically the four possible cases of curved refracting sides, concave-concave, convex-concave, convex-convex and concave-convex, for which the reflecting side is convex, straight or concave. He compares the respective corresponding advantages both from an optical and from a manufacturing point of view, and concludes in favour of a catadioptric profile, in which the two refracting sides are concave and the reflecting side convex, but of stronger curvature than in the usual profile. This concave-convex-concave profile has two advantages over the latter: (1) Easier and more accurate production of all three sides; (2) Smaller theoretical spherical aberration.

The article is illustrated with two examples of catadioptric

profiles plotted graphically by a method considered more convenient than that of Mr. Chr. Nehls, and with the design of the optical elements of the electric light apparatus of Arkona.

A. Br.

Circulation of Water in Boilers. Dr. Russner.

(Mittheilungen aus der Praxis des Dampfkessel- und Dampfmaschinen-Betriebes, Berlin, vol. xxvi., 1903, pp. 1017, 1057.)

The Author devised a thermopile whose leads were isolated by means of indiarubber and glass tubes in such a manner that the junction could be inserted into a boiler and brought into contact with the heating-surface. He was thus able to detect differences of temperature up to 36° F. between the water at a distance of $\frac{3}{8}$-inch from the plate and the plate itself. This maximum difference only occurred as long as the water was cold. Gradually, as the water-temperature rose, the temperature-difference decreased, until it vanished entirely, when actual boiling took place. These experiments, which are illustrated, were repeated on the sides of a copper vessel, where the same results were obtained. The Author does not mention whether there was a temperature-gradient in the water. He refers to similar results obtained at the Berlin Technische Reichsanstalt.

C. E. S.

Steam-Consumption of Steam-Turbines in relation to their Use for Ship-propulsion. Brosser.

(Bulletin de L'Association Technique Maritime, 1903, p. 163.)

Considering a single-disk turbine of the de Laval or Pelton type, driving a dynamo at constant speed, if P_1, t_1 be the pressure and temperature of the steam at admission, P_2, t_2 the pressure and temperature in the condenser, V the velocity of the steam issuing from the jets, given by the formula $V = 91^{m}\sqrt{t_1 - t_2}$, γ its specific weight, s the total sectional area of the jets, ρ the efficiency of the disk, the weight of steam used per second is $sV\gamma$, producing work at the axle $= sV\gamma.\frac{V^2}{2g}\rho$. The horse-power transmitted to the dynamo is $F = \frac{1}{75.2g}s \cdot V^3\gamma\rho$, and the consumption per effective horse-power is $g = \frac{3{,}600\ s\ V\gamma}{F} = \frac{5{,}300{,}000}{\rho V^2} = B\frac{s^{\frac{2}{3}}\ \gamma^{\frac{2}{3}}}{\rho^{\frac{1}{3}}\ F^{\frac{2}{3}}}$. If the governor were to act by reducing the total sectional area of the jets, without affecting P_1, the velocity V, and consequently ρ, would remain theoretically constant, and the consumption per horse-power would

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after passing through a cylinder is cooled in a condenser, the liberated heat being utilized to evaporate water which has previously been heated in an economizer warmed by the gases escaping from the boiler. The generated steam is also passed through a cylinder into a condenser, and here its heat is utilized to evaporate ethylamine, previously heated in an economizer which is warmed by the gases escaping from the first economizer. The vapour, after passing through its cylinder is condensed in the usual way. The Author then estimates the capacities of the cylinders and the surfaces of the boilers and condensers. He also deals with engines in which other fluids are used, but which lead to less favourable results, and he adds tables of the entropy and the latent heat of evaporation of aniline and sulphurous acid.

C. E. S.

The Diesel Motor.[1] M. Schröter.

(Zeitschrift des Vereines deutscher Ingenieure, 1903, p. 989.)

The Paper from which the following particulars are taken was nominally on the Engineering Industries of Bavaria, but the most prominent subject in it is the Diesel oil-motor, the original makers of which were the Augsburg Engineering Co., of Bavaria. The first motor was completed in February, 1897, of 20 HP., and had a total efficiency of 25·7 per cent. To indicate the progress made, the Author states that for a 120-HP. three-cylinder motor built towards the end of 1902, the total efficiency as determined by Professor Lundholm, Stockholm, was 36·8 per cent. at normal load, being an improvement of 43 per cent. on the former efficiency. The principal factors in the progress made have been: (1) the increase in thermal efficiency through improvements in the inlet-nozzles for the oil and the oil-pump; (2) the increase of mechanical efficiency through perfecting of the manufacture and simplification of the construction, such as, for example, diminishing the size of the air-pump, doing away with the cross-head, and general application of ring lubrication. These improvements have had the further effect of diminishing the weight and the price of the motor from 1899 to 1903 by amounts varying between 25 and 35 per cent.

The Diesel motor has been applied for driving the dynamos in a tramway power-station in Kieff (Russia). There are four groups of motors, each group being of 400 HP. normal and 500 HP. maximum performance. Each group has four working-cylinders of 450 millimetres (17·67 inches) diameter and 650 millimetres (25·6 inches) stroke. With three groups (twelve cylinders) in constant work for a year at 16 hours per day, about

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[1] Minutes of Proceedings Inst. C.E., vol. clv. pp. 467, 468.

4 million kilowatt-hours of energy are generated. The fuel used is raw naptha at about 4*s*. 6*d*. per 100 kilograms (about 45*s*. per ton, or one farthing per pound). The guaranteed consumption was not more than 308 grammes (10·8 ounces) per kilowatt-hour, so that the cost of fuel is about 1⅓ pfennig (about one-sixth of a penny) per kilowatt-hour. Another interesting application is where two alternators are worked in parallel, one by a turbine having no self-regulation and a Diesel motor with a regulation varying in speed by 20 per cent. The Diesel motor has also been fitted for propulsion to a barge on the Rhine-Marne Canal. The motor is of 20 HP., having two cylinders giving an almost perfect balance. No special attendant is required, the steersman doing all that is necessary.

J. G.

Test of Suction Gas-plant and Gas-engine. KURT BRÄUER.

(Zeitschrift des Vereines deutscher Ingenieure, 1903, p. 157.)

In suction gas-generators the steam which is used to pass through the burning fuel is produced by the heat of the gases passing off at the top of the generator. Not only does this directly economise heat, but the resulting gas is practically ready for use in gas-engines without requiring to be specially cooled. The greatest possible efficiency of the Siemens generator is 0·7, whereas with suction plant this limit may be as high as 0·95. The Author enters with great detail into consideration of the reactions taking place in the various parts of the generator, and applies the equations obtained to the data furnished by the testing of a suction gas-plant in the engineering works of Moritz Hille near Dresden. The gas produced was used to drive an engine having a cylinder 330 millimetres (13 inches) diameter, 460 millimetres (18·1 inches) stroke, and running at 200 revolutions per minute. The pressure of explosion was 32 atmospheres (455 lbs. per square inch), and the mechanical efficiency of the engine was 80 per cent. at 31·68 HP.

From the results of the tests the efficiency of the gas-plant was found to be 85 per cent., and calling the calorific value of the gas as it passes out of the generator 100, this is utilized as follows:—

	Per Cent.
Heat equivalent of work indicated in cylinder	29·8
Heat abstracted by cooling-water	37·2
Heat of exhaust gases	30·2
Radiation and conduction	2·8
Total	100·0

The detailed calculations are given; the heat of the exhaust gases was determined by calculation as well as direct measure-

ment and the difference was only trifling The fuel consumed in the generator per brake horse-power developed by the engine per hour was 0·41 kilogram (0·9 lb.) making the total efficiency 20·4 per cent. Comparing this performance with that of the steam-engine, the Author says that the coal-consumption of the steam-engine of the same power as this gas-engine would be at least 0·85 kilogram (1·87 lbs.) per horse-power-hour.

The Author finally discusses the possible improvements in the generator and other parts of the plant, and calculates that it will be possible to reduce the coal-consumption to 0·32 kilogram (0·7 lb.) per horse-power-hour. At the price of 27*s.* 6*d.* per ton (metric) for anthracite the cost of fuel comes to 0·88 pfennig (one-tenth of a penny) per horse-power-hour.

J. G.

Packing by a Water-flush System in Silesian Collieries.

SCHREIBER.

(Glückauf, 1904, p. 59.)

The system of packing large excavations by the aid of a water-flush promises to become of great importance in coal-mining. It consists in carrying packing-material down into the mine by a current of water in pipes. The material is allowed to settle, whilst the water flows back to the shaft. The material used consists chiefly of sand and loam. In Upper Silesia granulated blast-furnace slag is largely used. The sand and water are mixed in equal proportions, the arrangements for mixing adopted at the Concordia colliery at the surface, and at the Hohenzollern colliery underground, being described by the Author. The material has to be introduced with great care, so that the excavations are filled to the roof. The effect on the surface is then hardly appreciable, whereas, if the roof of the excavation is allowed to fall in, the subsidence represents 30 to 70 per cent. of the original thickness of the seam. Levellings at the surface of the Myslowitz colliery showed that there was no subsidence at all. By the water-flush system loss in working and mine-fires are obviated. Indeed, at the Ferdinand colliery, a mine-fire that had broken out was confined by a belt of water-borne packing. Accidents caused by falls of rock and coal have been lessened. At the Myslowitz colliery, where the mortality caused in this way was very heavy, there have been no such accidents during the past two years. The consumption of timber is also considerably lessened. The total cost of packing by the new method at the Myslowitz colliery is 6*d.* per ton of coal, whilst the cost of dry packing at other Silesian collieries is 10*d.* to 1*s.* 10*d.* per ton of coal. By the employment of the new method at the Myslowitz colliery there was

aved, per ton of coal, 1·6*d.* in wages, 1·3*d.* in the cost of amming, and 1·1*d.* in timber, a total saving of 4*d.* Deducting his sum from the cost of packing, there is a net cost of 2*d.* per ton f coal.

B. H. B.

Available Energy of Fuels. C. Linde.

(Zeitschrift des Vereines deutscher Ingenieure, 1903, p. 1509.)

The Author reviews the subject generally, making use of the ϕ diagram to illustrate the relative economies of different kinds prime movers. The second law of thermodynamics furnishes e principle of economy; taking in of heat at the highest possible mperature and rejecting it at the lowest possible temperature.

Beginning with the burning of fuel under a boiler, the entropy-agram shows that in the ordinary case 40 per cent. of the total at is of necessity rejected. If only the bare sufficiency of air ere supplied for combustion the loss would fall to 28 per cent., aking the efficiency of the perfect cycle 72 per cent. Coming to e boiler there are two main sources of loss. In the transmission heat from the hot gases to the boiler, about 25 per cent. is lost the chimney, &c., but the most serious drawback is that the mperature falls from that of the burning fuel—highest value 500° C.—to the temperature of saturated steam, say at 10 mospheres, viz., 450° C. The final result is that only 25 per nt. of the heat of combustion is passed on to the engine. The uthor next analyses the way in which a compound condensing-gine, using 4·03 kilograms (8·9 lbs.) of steam per horse-power-ur, transformed this heat into work, the final efficiency being ·8 per cent. of the heat of combustion. The two principal urces of loss in engines are the initial condensation of steam on tering the cylinder, and the failure of this steam to expand and work much below 80° C., so that heat extraction begins at too gh a temperature. The first loss can be partly made up by perheating the steam, and the second by the use of waste-heat gines. The steam-turbine also avoids this latter loss to a great tent. Another loss, that due to the necessity of heating the feed-ater up to steam temperature, might be avoided by a process of iabatically compressing the mixture of steam and hot water, but is is impracticable. The Author next considers a steam-loco-otive, giving the indicator- and entropy-diagrams, as in the other ses. The steam was superheated to 290° C., the temperature of turation being 190° C. The absolute temperature was thus 3° C. Owing to the absence of a condenser the heat was stracted at above 100° C., and the range of temperature, instead being 463° was less than one-fifth, viz., about 90°. Finally, e indicated work was only 8·84 per cent. of the heat of mbustion.

The effectiveness of the waste-heat engine depends on the supply of cold condensing-water. In the case of a three-cylinder engine, the diagrams of which are given by the Author, the effect of the waste-heat engine was to add a considerable area to the lower part of the entropy-diagram, owing to the reduction of the temperature of heat-abstraction. The efficiency (ratio of indicated work to heat of combustion) was raised, in this case, from 12·4 per cent. without the sulphurous-acid cylinder, to 17·14 per cent. with it, making the total efficiency 15·56 per cent. The steam-turbine does not utilise the upper regions of temperature so well as the reciprocating steam-engine, but it fills up the lower part of the entropy-diagram better. The best results hitherto obtained have been with the Parsons turbine in Frankfort, by Messrs. Brown, Boveri and Co., the consumption of steam, with an output of 3,500 kilowatts, being 6·5 kilograms per kilowatt-hour (10·9 lbs. per horse-power-hour). Allowing a boiler efficiency of 75 per cent., this gives a total efficiency of 15·45 per cent. The steam was superheated to 300° C. The Author suggests that the reciprocating steam-engine might be used for the steam at high pressure, and it would then be passed on to a turbine to utilise down to a vacuum of 93 per cent. The Author mentions oil and aniline as liquids capable of extending the temperature limit upwards, in the same way as sulphurous acid enables the limit to be lowered.

The great disadvantage of the steam-engine is that the temperature reached in the combustion of the fuel is not maintained in the steam, and this fall of temperature takes place without the performance of work. The internal-combustion engine, on the contrary, does not suffer from this fall in temperature, and in addition to this the compression shifts the whole work process into higher temperature-regions, and this at once diminishes the heat which would otherwise be inevitably thrown away. The limits to the degree of compression are twofold: first, the strength of the materials, and secondly, the dissociation of carbonic acid and water vapour. The process which would give the highest possible efficiency is as follows:—adiabatic compression from the temperature of the atmosphere to near the limit of dissociation, taking in of heat along the limit temperature of dissociation, and finally adiabatic expansion down to the temperature of the atmosphere, at which the unavoidable throwing away of heat may then take place. In the Otto four-cycle gas-engine, the indicated work, the heat given to the cooling-water, and that passing off in the exhaust, are each about one-third of the calorific value of the fuel, the total efficiency being about 29·4 per cent. For the Diesel oil-engine the total efficiency is 32·1 per cent. The Author looks to improvement of the heat-diagram of the combustion motor in the direction of avoiding the loss shown at the lower temperature limit. He next discusses producer-gas and blast-furnace-gas motors. In one case gas produced from a poor quality of brown coal gave a total efficiency, from calorific value of coal to useful work, of 22·4

cent. An engine worked by blast-furnace gas gave a thermal ciency of 34 per cent., but owing to low mechanical efficiency total efficiency was only 24·6 per cent. The Author finally cusses generally the subject of the distribution of power, light l heat from central situations, setting forth the various claims gas, steam and electricity. J. G.

The Calorific Value of the Flame of Different Fuels.

P. MAHLER.

(Revue Universelle des Mines, 1904, p. 1.)

The Author, having determined the calorific value of numerous els in his bomb calorimeter, has from these results, combined with ose of elementary analyses, completed the flame temperatures tainable with fuels of various kinds, when burnt with air at 0° d 760 under pressure by a method based on the work of Messrs. allard and Le Chatelier in the French Fire-damp Commission, hich is somewhat similar to that adopted by Mr. Blaas, of Essen, his paper on water-gas flame temperatures, published in 1892. his is too detailed for reproduction in full, but the results are ven in the following tables :—

—	Calorific Value.		Flame Temperature.
	Higher (Water Condensed).	Lower (Water as Vapour).	
	Calories.	Calories.	°C.
k wood, Lorraine	4,690	4,370	1,865
at, Bohemia	5,900	5,590	2,020
gnite Trifail, Styria	6,650	6,370	1,960
laming coal, Blanzy	8,350	8,060	1,990
„ „ Decazeville	7,840	7,530	1,960
xidised (weathered) coal, Commentry	6,380	6,200	1,960
as coal, Commentry	8,410	8,110	1,950
„ „ Bethune	8,670	8,380	1,990
„ „ Lens	8,740	8,450	2,010
oking coal, S. Étienne	8,860	8,580	2,010
mithy „ Roche la Molière	8.860	8,600	2,030
emi-bituminous, Anzin	8,660	8,430	1,980
nthracitic, Commentry	8,460	8,290	2,030
„ Kebao, Tonkin	8,530	8.370	2,020
„ Creusot	8,690	8,480	2,010
ennsylvanian anthracite	8,266	8,140	2,000
thylic and methylic alcohol	..	..	1,700
mylic alcohol	..	..	1,850
rude American petroleum	..	10,400	2,000
etroleum spirit, American	..	10,270	1,920
efined petroleum, American	..	10,280	1,C60

For the following gases at constant pressure the values are :—

	°C.
Hydrogen	1,960
Carbon monoxide	2,100
Methane	1,850
Acetylene	2,350
Illuminating gas, average	1,950
Water-gas in industrial use	2,000

Or the flame temperatures of all fuels burnt with air are nearly alike.

A comparison of these figures seems to lead to the paradoxical conclusion that, of two fuels, that with the higher calorific value will not necessarily give the hotter flame. Thus the flame of petroleum spirit is relatively cold, while that of peat is hotter than that of the best Saint-Étienne coal whose calorific value is about one-third higher. The true measure of value is however high calorific value, because the body of flame for the coal is much larger than that of the peat, a substance containing much oxygen and therefore requiring less air for its combustion. For example, 100 grammes of the peat in question give rise to 28 volumes of gas at 2,000°, while the coal gives 44 volumes at the same temperature.

The use of hot blast for improving the flame seems from the thermometric point of view to be more efficacious in coal-fired furnaces than in those using fuels of an inferior character.

H. B.

New Gas-producing Plant.

(The Engineer, 11 December, 1903, p. 578.)

Messrs. Crossley Bros. have introduced a new system of producer-gas plant for use in connection with gas-engines, and for other purposes. It consists of a cylindrical fire-brick lined chamber—the producer proper—into which the fuel is introduced by means of two feed-hoppers on the top, to be used alternately at intervals of an hour or more. Air and steam pass upwards through the fuel, combining with it to produce gas, which is taken away by a central collecting-bell at the top. At the bottom of the cylinder is a water lute, to enable the ashes and clinkers to be withdrawn without interfering with continuous work, also inspection-doors for rotating the grate, which saves poking. The heated gas is conducted into a saturator, consisting of an inner and outer pipe, the space between the two being filled with water to a certain height. The hot gas passes down through the inner pipe, imparting the bulk of its heat to the water, which becomes very hot at the top, and gives off steam. The air-supply from a fan is blown round the top part of this saturator, where it mixes with the steam and passes down the annular space between the two casings of the

roducer, and is led underneath the rotatable perforated conical grate. The gas bubbles through a hydraulic box at the bottom f the saturator and passes into a coke scrubber, in rising through which it meets a small quantity of water trickling through the oke and becomes further cooled. It is then passed through a awdust scrubber, when intended for use in an engine. No steam-oiler is required, and no gas-holder. After starting the gas-making by means of a small hand-fan attached to the producer, the urther production of gas is continued by the suction of the engine tself. Bituminous coal may be used instead of coke or anthracite, ut more labour is required in cleaning in this case.

A. W. B.

A Reversed-combustion Gas-producer. I. DESCHAMPS.

(Bulletin de la Société de l'Industrie Minérale, 1903, p. 889.)

This is a new system of down-draught producer intended to be ised with fuels of low calorific value which give too large an mount of condensable products to be suitable for gas-engine use. It consists essentially of a nearly cylindrical stack lined with fire-brick, with a larger funnel-shaped chamber for feeding above and n inclined grate in a closed and water-sealed ash-pit from which the air is excluded. An empty space preserved by a central tube through about one-third of the height of the column of fuel serves for the admission of the air for combustion, which is previously heated by passing through a continuous spiral pipe placed in the outlet passage of the gases. By this means active combustion is confined to the centre of the mass of fuel, and the gaseous products have to pass downwards to the grate, where the fuel is for the most part reduced to ashes and scoriæ, but as the temperature is low there is no great formation of clinkers even with very dirty fuel. The working is regulated by an exhauster, which draws off the gases through the scrubbers and forces them into the gas-holder. The air is further heated by passing it through the exhaust of the gas-engine, a small amount of the burnt gas of the latter being introduced at the same time. The plant has been erected for experimental purposes at Montreuil, and trials of various fuels have been made. The first of these, a lignite from Marseilles, with much ash but free from water, gave some trouble at first from the tar deposited in the exhauster-box, but this improved as the producer got hotter. The rate of consumption was 53 kilograms, or 100 kilograms per square metre of section of the producer, per hour. A second trial with an earthy lignite from the Landes failed to give a combustible gas when tried alone. Better results were obtained with Russian fuel containing 25 per cent. of moisture and of specific gravity 0·625. This gave an excellent gas for motor purposes, and the valves of the engine were quite clear after

continuously running for 9 days. The consumption was 102 kilograms per hour or 190 kilograms per square metre, or sufficient to supply an engine of 100 HP. Other trials with bituminous coals gave satisfactory results, especially as regards the tar in the gas, which, with the coal of St. Eloy, amounted to 1·91 gramme per cubic metre, while the same coal when gasified in the Krupp producers gave 43 grammes on an average. Trials were also made with spent tan containing 70 per cent. of water: this, like the lignite previously noticed, could not be used alone, but a certain degree of success was obtained when it was mixed with about 19·5 per cent. of small coal.

H. B.

Blast-Furnace Gas-Engine Plant at the Kladno Ironworks.

K. Machacek.

(Zeitschrift des Oesterreichischen Ingenieur- und Architekten-Vereines, 1903, p. 618.)

In supplementing the electrical power-plant at the Kladno ironworks with a 600-HP. blast-furnace gas-engine, the designing of the latter was complicated by the necessity for parallel working with the existing steam-driven dynamos. The difficulty was overcome by employing a four-cycle engine of the Delamare-Deboutteville type (constructed by Messrs. Breitfeld, Danek and Co.), with two pairs of tandem cylinders, and fitted with an air-pump regulator and an electric fly-wheel brake to maintain uniformity of impulse under fluctuating load. As a further check on irregularity, a throttle bobbin was provided to automatically increase the resistance opposing the equalizing current between the two sets of generators.

One of the chief working difficulties encountered was that of freeing the gas from dust. The ventilating fan at first erected for this purpose proved insufficient, since, even with a 37½-inch fan, making 950 revolutions per minute, the engine could not take a higher load than about 300 HP., but on supplementing the fan with a larger one (diameter 43¼ inches), running at 900 revolutions, the full indicated power of the engine was attained, though at a total expenditure of 50 HP. (or 8 per cent. of the whole) for driving the fans. This works out much higher than the experience with larger plants in Luxemburg; but experiments now in progress at Kladno are said to give better results.

The dimensions of the engine are: cylinder-diameter 700 millimetres (27·55 inches), stroke 800 millimetres (31½ inches) speed 150 revolutions per minute, corresponding to a piston velocity of 4 metres (13 feet) per second. The direct-coupled dynamo is a twenty-pole polyphase current generator, for a tension of 550 volts, with 25 periods per second. The magnet coil is wound with one hundred and thirty turns of 7·5-millimetre (0·29-inch wire, and

the armature is provided with one hundred and twenty grooves, each containing two circular rods 20 millimetres (0·78 inch) in diameter. The throttle-bobbin is constructed for 30 volts and 575 amperes per phase, with three adjoining cores, wound transformer-fashion, with ten turns of three 13-millimetre (0·51-inch) wires on each.

C. S.

Blast-Furnace Gas as the Sole Motive Power of Ironworks.

K. Gruber.

(Stahl und Eisen, 1904, p. 9.)

This is a detailed study of a scheme for working a large basic steelworks with power derived from the blast-furnaces and coke-ovens alone. The Author proposes to have four blast-furnaces, each of 300 tons daily capacity, with four 18-ton basic converters, two 25-ton basic Siemens furnaces. Two large reversing cogging and heavy-section mills, three-high mills, a small merchant and wire mills, the two latter being only worked alternately. The available gas, after satisfying the demands of the blast-heating stoves, is computed to be equivalent to 31·2 HP. per ton of pig-iron made, or, deducting 7·5 HP. for the lifts and blowing-engines, circulating-pumps, etc., supposing them to be driven by electric motors, there will be 23·7 HP. per ton, or 28,400 HP. in all, available for the steelworks. This is on the basis of 20 cwt. of coke per ton of pig-iron; but, as the consumption in smelting minette ores is generally about 22 cwt., the amount available will be increased to 33,000 HP. The distribution would be as follows:—

1. *Central Electric Station.*—To contain five gas-driven generators of 500 HP., four in use and one in reserve, giving a maximum of 2,000 HP., or an average daily output of 1,000 HP., 250 HP. going to the blast-furnaces, and the remainder to the steelworks.

2. *Bessemer Blowing-Engine.*—The conditions necessary for this work—reliability, immediate development of full power at starting, and capacity for rapidly varying the air-pressure—could best be met by an independent electric plant; but this is not recommended, on the ground of expense. The solution proposed is a gas-engine of 3,000 maximum, or 1,500 average HP., to be run at reduced speed during the intervals of blowing charges. This would mean running unloaded for about 4 hours in the 24 hours, and would only increase the gas-consumption per useful horse-power of work about 5 per cent.

For the heavy-section and cogging mills steam-motors are preferred, the former of 1,750 and the latter of 2,750 average HP. The requirements of the other mills are as follows:—

Heavy bar mill	1,250 HP.
Medium „ „	750 „
Light „ „	500 „
Wire „ „	500 „

These are all three-high, and driven by gas-engines, a spring friction coupling being inserted between the motor and the rolls, which is only thrown into gear when the former has been brought up to full speed. From 55 to 60 per cent. of the total gas-supply would be required for power, and a margin of about 10 per cent. would remain after satisfying the requirements of the open-hearth and reheating furnaces, as shown in the following summary:—

	Cubic Metres.
Steam raising for reversing-mills	756,000
Gas-motors for three-high mills	378,000
Soaking-pits and reheating-furnaces	438,750
Open-hearth melting-furnaces	253,500
	1,826,250
Surplus	213,750
Total production of gas in 24 hours	2,040,000

If a coking-plant were added the conditions would be much more favourable; the gas from a battery of ovens producing 1,200 tons of coke daily amounts to 442,400 cubic metres, and of this about 60 per cent. is consumed in heating the ovens, and 10 per cent. by the accessory motors. The surplus of 160,000 cubic metres, owing to the high calorific value of the gas, represents about 10,534 HP. This might best be utilized in the open-hearth furnaces, and might, like natural gas, be supplied to the furnace directly from the by-products condenser without reheating, in the same way as natural gas is used in America.

A further development of power is indicated in the application of low-temperature vapour-engines, to be worked by the waste heat of the exhaust of the various motors, which mounts up to the startling total of 18,650 HP., so that the surplus, after satisfying all works' requirements, comes out as follows:—

	HP.
From surplus blast-furnace gas	3,000
,, ,, coke-oven ,,	9,500
,, low-temperature vapour-engines	18,650
	31,150

The total amount of water required for gas-cleaning, boiler-feeding, and engine-cooling, is estimated at 5,215 cubic metres per hour, under the following heads:—

	Cubic Metres.
For cleaning the blast-furnace gas	1,752
,, cooling gas-engines	1,334
,, steam-boiler feeding	756
,, low-temperature condensing engines	1,343

This is apart from the consumption of the coal-washing and coking plant, and the tuyere and other cooling water in the blast-furnaces. In any case, however, as the water requirements of gas and steam-

engines are in the ratio of 2 to 7, it is evident that the water charge will be diminished when the former power is substituted for the latter. H. B.

An Electric-driven Crane for Bessemer Works.

A. DONDELINGER.

(Stahl und Eisen, 1904, p. 16.)

In a new basic Bessemer works recently erected by the Chatillon-Commentry Company at Neuves Maisons, the entire manipulation of the ladle, both for charging and casting, is effected by overhead traversing cranes worked by electric motors. The shop is planned to contain four 18-ton converters and two gas-heated mixers, each of 220 tons capacity, but only three of the former and one of the latter are at present in use. They are all placed with their axes in one line, about 70 metres long, with the mixer at one end. The crane which runs parallel to this line, upon overhead rails carried upon pillars about 40 feet high, has a span of 15 metres, with a maximum lifting-power of 35 tons, which load can be lifted 6 metres, moved sideways 10 metres, and, longitudinally, through the entire length of the shop; the working-speeds under the maximum load being 3, 20 and 80 metres for the different movements respectively. The ladle is suspended by trunnions resting in open hooks at the ends of a pair of screwed rods, which can be raised or lowered by a reversible motor with worm-wheel gearing on the traversing platform. The tipping is done by two similar rods, which bear against stops on the outside of the ladle. The metal from the blast-furnace, brought by a steam-locomotive upon an elevated railway, about half the height of the shop, is lifted by the crane to the receiving-mouth of the mixer and poured in; the same ladle also takes the charge for the converters. The finished steel is taken by another ladle to the ingot-moulds, which are mounted on bogies on a transverse line at the opposite end of the building, the same crane being used. This, however, is only a temporary arrangement, as a second crane, in course of erection, is to be provided for handling the finished steel, the first being reserved entirely for the mixer and for charging the converters. The crane driving-station is upon a platform suspended from one of the main girders which carries the starting and reversing gear for the four different movements, as well as the switchboard. Direct current at 500 volts is used with series-motors capable of bearing a considerable overload; the transmission is partly by leathered gearing with raw hide pinions, and partly by leather belts with elastic couplings, in order to insulate the electric from the other working parts. The girder work of the crane has been built by Messrs. Bietrix, Laflawe and Company, of Saint Etienne, and the electrical parts by the Westinghouse Company.

H. B.

The Effect of Limestone in Foundry Cupola Working.

A. Sulzer Grossmann.

(Stahl und Eisen, 1904, p. 28.)

This is an account of experiments made in the foundry of Messrs. Sulzer Brothers in order to determine the effect of varying additions of limestone upon the composition and properties of cast-iron when melted in a cupola with Westphalian coke, containing 8·7 per cent. of ash and 1·3 per cent. of sulphur. The metal used was a mixture of half scrap, half new pig-metal, the latter of the following composition:—

—	Si.	Mn.	P.	S.	Weight.
					Kilograms.
Harrington No. 3	2·38	0·12	0·041	0·02	100
„ No. 4	1·45	0·12	0·043	0·05	50
Alabama No. 4	2·83	0·42	0·91	0·044	100

The charges were 500 kilograms of metal to 30 kilograms of coke, and from 15 to 20 tons were melted in each experiment. The flux, a pure Swiss limestone, with 57 per cent. of lime and 3 per cent. of silica, was added in varying proportions, from 0 to 10 per cent. of the weight of the charge, or 0 to 33 per cent. of that of the coke. The composition of the metal melted under these different conditions was as follows:—

—	0	1	2	3	4	5	6	7	8	9	10
Limestone per cent. of charge	0	1·0	2·0	3·0	4·0	5·0	6·0	7·0	8·0	9·0	10·0
Limestone per cent. of coke	0	3·3	6·6	10·0	13·3	16·6	20·0	23·3	26·6	30·0	33·3
Silicon . .	1·44	1·50	1·70	1·78	1·61	1·56	1·75	1·57	1·38	1·48	1·57
Manganese .	0·35	0·38	0·37	0·39	0·40	0·35	0·37	0·41	0·60	0·37	0·39
Phosphorus .	0·48	0·51	0·50	0·54	0·43	0·55	0·54	0·53	0·69	0·49	0·54
Sulphur . .	0·128	0·156	0·133	0·140	0·114	0·101	0·116	0·102	0·09	0·085	0·10

The variation in the limestone seems to have no effect upon the properties of silicon or manganese, but the sulphur diminishes very rapidly, being reduced by 44 per cent. with the largest additions.

From each series, four bars, 1 metre long and 30 millimetres square, were cast for the bending tests, and for their fractures tensile-test pieces were turned down to a tapered circular section of 18 millimetres diameter in the middle and 200 millimetres long between the ends. The impact tests were made on bars, 40 millimetres square between supports, 160 millimetres apart, with a falling weight of 12 kilograms and an initial drop of 300 millimetres, which was increased 100 millimetres at every successive

blow. The compression tests were made on cubes 30 millimetres in the side, cast from the bending-test pieces, and were carried out at the Federal Testing Institute in Zurich. The results are contained in the following table:—

—	0	1	2	3	4	5	6	7	8	9	10
Bending strength, kilograms per square millimetre[1] . . .	27·9	28·5	28·7	29·3	29·5	31·2	32·0	32·8	34·3	32·5	33·5
Depth of bend, millimetres	18·6	22·5	22·5	22·5	22·5	22·5	22·5	23·0	22·5	23·5	23·2
Tensile strength, kilograms per square millimetre . . .	16·8	17·3	17·6	18·3	18·3	20·3	19·8	21·2	20·1	20·5	21·2
Height of fall of breaking tup, centimetres .	35·0	35·0	37·5	40·0	40·0	42·5	45·0	45·0	45·0	45·0	45·0
Compressive resistance tons per square centimetre	8·6	9·2	8·9	8·8	8·9	8·8	9·3	9·0	9·0	10·2	9·9

There is some doubt about No. 8, where the Author supposes that some stronger iron from cylinder-castings may have been accidentally included in the charge, giving a lower proportion of silicon in the mixture.

The quantity of slag formed varied with the limestone added, between 23 kilograms and 81 kilograms per ton of iron melted, and the actual loss in melting by scorification, between 0·784 and 1·626 per cent., apart from that mechanically entangled in the slag. Even this amount is above the real quantity, as the iron found by the analysis in the slag is, in great part, derived from the ash of the coke. The Author therefore points out that the figures given for the loss of iron by oxidation in the cupola are, as a rule, too high.

H. B.

Structure and Properties of Silicon Steels. L. GUILLET.

(Comptes Rendus, vol. cxxxvii., 1903, p. 1052.)

The Author has made a micrographic investigation of the structure of steels containing different percentages of silicon, and has tested their mechanical and physical properties. His examination shows that among such steels only those containing less than 5 per cent. of silicon can be used. Confining his tests to this class, he finds they offer greater resistance to shock after tempering than before, and that this resistance is relatively high where the percentage of carbon is high. The breaking stress and the elastic limit are higher in these silicon steels than in ordinary steels with

[1] 1 kilogram per square millimetre = 0·635 ton per square inch.

the same percentage of carbon, but they do not increase sensibly with the amount of silicon. Their resistance to shock is lower, while their hardness is greater, than in ordinary carbon steels. The experiments seem to prove the existence of two solutions of silicon in iron; one would probably be the solution Fe — Si, the other the solution Fe — Fe_2Si.

W. C. H.

Deterioration of Mild Steel. L. BENJAMIN.

(Mittheilungen aus der praxis des Dampfkessel- und Dampfmaschinen-Betriebes, Berlin, 1903, p. 1040.)

The Author refers to a previous Paper in which he describes the fracturing of a mild steel plate which formed part of a steamer built 12 years ago, and mentions that the fractured plate, as well as those adjacent to it, gave every indication of having once been ductile. The analysis of the broken plate was as follows: C = 0·045, Mn = 0·48, P = 0·124, S = 0·05 per cent. Tensile and bending tests showed the material to be brittle. On heating it to bright redness, and quenching it in warm water, its ductility was so much improved that a sample could be bent through 180°.

C. E. S.

Strength of Steel at High Temperatures. C. BACH.

(Zeitschrift des Vereines deutscher Ingenieure, 1903, p. 762.)

Bars from three different works were tested, these being distinguished by the letters O, K, and M. Of the bars O, four were subjected to tensile tests at ordinary temperatures, and successive lots of four to tests at the temperatures, 200°, 300°, 400°, 500°, and 550° C. At ordinary temperatures the strength of the steel was—for bar No. 2, for example—4,267 kilograms per square centimetre (27 tons per square inch), the ultimate extension on a gauge-length of 8 inches 26·3 per cent., and contraction of area 46·9 per cent. The results of the tests showed that the strength increased up to 300° C. by about 500 kilograms per square centimetre (3·17 tons per square inch), and from this temperature onwards the strength fell, roughly in proportion to the temperature, to 2,070 kilograms per square centimetre (13·1 tons per square inch) at 550° C. The ultimate extension decreased from 25·5 per cent. at ordinary temperatures to 7·7 per cent. at 200° C., from which it rose again to 39·5 per cent. at 550° C. The contraction of area also fell at 200° C. but did not begin to rise until the temperature was above 300° C. In the case of the bars from the works distinguished by the letters K and M, tests were made by keeping the loads on for a considerable time. This prolonging of the action of

the load had no effect until the temperature reached 300° C., at which point it caused a slight decrease of strength, and at 400° and 500° a greater decrease. Prolonged loading between the temperatures of 300° and 400° C. caused an increase in both the extension and the contraction, but from 400° C. the extension and the contraction under prolonged loading decreased until at 500° C. they were lower by from 20 per cent. to 25 per cent. than under a test of ordinary duration.

The Author draws from his investigations the conclusion that for steam-boilers, piping, etc., the strength of steel should be tested at the higher temperatures; and he is of opinion that this conclusion is justified not only by his experiments but from the well-known fact of the brittleness of steel when worked at a blue heat.

J. G.

Prevention of Pipes and Cavities in Steel Ingots.

JULIUS RIEMER.

(Zeitschrift des Vereines deutscher Ingenieure, 1903, p. 1674.)

In a steel ingot without a head or riser there is a tendency to the formation of a core or a number of cavities in the region of the latest solidification, that is, somewhere towards the top of the ingot. To avoid such cavities the compression of ingots has been and is still practised, but the process is costly, and the Author describes a new process he has invented and patented, which is specially applicable to large steel ingots intended for forging. Siemens-Martin ingots free from the core above referred to are worth from 7*s.* 6*d.* to 9*s.* per ton more than ordinary ingots, and the Author's process does not involve an expenditure of much more than half this amount. The method is to keep the top of the ingot in a liquid condition for some time after the metal is teemed, by closing the upper end with a kind of cap, through the top of which highly heated air and gas are blown. These burn on uniting, and the stream of flame is directed on to the top of the metal, the waste gases escaping at other holes towards the outer edge of the cap. It is found that for the efficiency of the process a temperature far above the melting-point of the metal is necessary, and, in the attainment of this, the heating of the incoming air and gas is of the utmost importance. The Author gives particulars, such as chemical analyses, etc., with illustrations, of blocks of steel treated by his process, showing how all the voids and cavities are concentrated within a short distance below the top of the ingot, the whole of the metal below this being practically solid.

J. G.

An Electric-driven Rolling-Mill.

(Stahl und Eisen, 1903, p. 1372.)

At the Bethlen Falva steelworks in Upper Silesia, a large electric-driven plant for the production of merchant bars and sections from steel blooms has been at work since August, 1903. It includes three groups of three-high mills, each having an independent direct-coupled motor and fly-wheel. The driving power is derived from the general service-mains of the Upper Silesian Electricity Works as alternating current at 5,800 volts, which is received by an alternating-induction motor of 600 HP. and transformed to direct current at 510 volts by a compound-wound dynamo with a capacity ranging from 500 kilowatts normal to 1,000 kilowatts maximum output, the number of revolutions varying from 365 to 300 per minute, the variations in the demand of the work being equalized by a 20-ton cast-steel fly-wheel. The three rolling-mills include (1) a blooming or roughing train of a single stand of 18-inch rolls, making 60 to 100 revolutions; (2) a medium train with two stands of 14-inch rolls making 150 to 230 revolutions; and (3) a small-section mill with seven stands of 10½-inch rolls (to be subsequently increased to nine) running at 300 to 460 revolutions per minute. The motors of the roughing and medium trains are each of 200 average and 600 maximum HP.; the first has a 12-ton and the second an 8-ton fly-wheel. The small-section mill has a motor ranging between 300 and 800 HP., with a 5-ton fly-wheel. The roughing-mill takes steel blooms 8¼ inches square, weighing 5 cwt., which can be finished to bars 50 to 65 metres long, but as a rule the blooms are only reduced to 2⅜ inches square, and then sheared into lengths for finishing in the smaller mills, which roll bars up to lengths of 35 to 45 metres in the medium-section, and 65 to 100 metres in the small-section train. The transformer fly-wheel is so proportioned that the driving effort on the transforming dynamo-axle may be raised to 1,000 HP. for a period of 16 seconds when the demand of the mills for energy is large, the alternating motor maintaining its average output. The actual demand for energy varies with the nature of the work in hand, but may be taken to vary between 250 and 450 kilowatts. The whole of the electric machinery, including the transformer plant and the mill-motors, is contained in an oblong building which is completely enclosed and separated from the rolling-mills, which are arranged in three parallel lines at right-angles to the longer side of the building.

H. B.

The Physical Properties of Copper. PAUL GALY-ACHÉ.

(Annales de Chimie et de Physique, 1903, p. 326.)

The first part of the Paper consists of an enquiry into the working and accuracy of the testing-machines used. These are so designed that the pull or the thrust is taken up by a piston resting on mercury. The experiments were fairly numerous, and were carried out for the purpose of interpreting the deformations of copper crusher-gauges which are used for recording powder-pressures. It was found that the breakdown point for compression is always raised to the level of the previously applied stress, which can therefore readily be ascertained by testing a used crusher-gauge and noting its breakdown-point. Also, that the amount of compression was greater under the drop-test than in the testing-machine, but this discrepancy has been fully accounted for by the lowering of the breakdown-point due to the raising of the temperature by a blow. The breakdown-point was found to decrease from 10 tons per square inch at $-58°$ F. down to 8·5 tons at 392° F. Annealing temperatures were found to affect the breakdown-point of copper very materially. In an unannealed sample this limit was 9·3 tons per square inch, but fell to 0·64 ton in a sample annealed at 1,832° F. It was further noticed that for equal elongations the acquired breakdown-point in tensile test-pieces was greater with rapid (drop) testing than with slow testing. Only one experiment is quoted in support of a statement frequently repeated throughout the Paper that the breakdown-point for compression is equal to that for tension, even if the latter is artificially raised by stressing. This is quite contrary to the accepted deductions from Wöhler's experiments, according to which the artificial raising of the one limit lowers the other. The Paper concludes with instructions for preparing microscopic slides of copper and with deductions drawn from their examination. It appears that the crystalline structure grows coarser with increasing annealing-temperatures, and that compression-stresses tear up these crystals.

C. E. S.

Engineering and Chemistry. W. OSTWALD.

(Zeitschrift des Vereines deutscher Ingenieure, 1903, p. 1241.)

The Author after a general survey of his subject points to the conversion of solid fuel into gas as a problem requiring the co-operation of engineers and chemists. At present the processes occurring in the gasification of coal and other fuels are almost entirely unknown. Whether the gas is obtained by external heat-

ing of the coal and by the use of steam, thus producing the so-called water-gas, or whether the energy necessary for the reaction is secured by the admission of air, the following reactions always occur:—

$$H_2O + C = H_2 + CO \text{ and}$$

$$2\,H_2O + C = 2\,H_2 + CO_2$$

Owing to the poisonous nature of carbonic oxide, it is of the utmost importance to be able to make the one or the other reaction predominate at will. The Author discusses the factors which influence the occurrence of these, one of the most important being the temperature at which the gas is produced. To avoid the formation of carbonic oxide, a low temperature is one of the requirements. But this condition is also that under which the greatest quantity of by-products is obtained, and as, amongst these, are liquid fuels and hydrocarbons applicable in chemical industry, the distillation at a low temperature of all kinds of solid fuel, in large central stations, appears to be one of the things to be expected in the near future. Further, one of the constituents of fossil coal is nitrogen, to the amount of 2 or 3 per cent. This escapes entirely in dry distillation, but it is possible to extract it from the gas by known means. This nitrogen can be utilized in agriculture, and would in fact be an immense benefit. By a process which the Author says he has discovered, but does not detail, it would also be possible to use the nitrogen thus obtained for the manufacture of powder and explosives, thus doing away with the present entire dependence on the saltpetre of Chili.

J. G.

Speed of Ships. B. Afonassief.

(Bulletin de l'Association Technique Maritime, 1903, p. 61.)

The object of this Paper is to obtain an equation giving the maximum indicated horse-power of the engines required to propel a vessel at a given speed in water of a given depth, and to find the maximum speed.

If H = maximum indicated horse-power developed, V = the maximum speed in knots, in water of mean depth T metres, h = indicated horse-power for a speed of v knots (less than the maximum speed) in water of the same depth, L = the length of the ship in metres measured on the line of flotation, B = the maximum breadth in metres, t = mean draught of the ship in metres, then $\frac{h}{H} = \left(\frac{v}{V}\right)^p$, where $p = 2 + i + C\,(1 - i)\,i^2$, i being $= \frac{v}{V}$, and $C = K\,10^{\mu - 0{\cdot}2}$, where $\mu = \frac{t}{T}$, and $K = \frac{L}{B}$.

Now the value of p tends towards 2 or 3 according as the ratio . decreases or increases. Between these limits p reaches its aximum for a ratio of the speeds $i_o = \frac{1}{3} + \sqrt{\frac{1}{9} + \frac{1}{3\,C}}$.

If the values of $\frac{h}{H}$ be plotted to a base of values of i, curves may be rawn, giving values of $\frac{v}{V}$ for given values of h and H, whence the aximum value of V may be found. The Author confirms the ccuracy of his deductions by means of tables and curves conructed from the results of speed trials on vessels of different ypes belonging to the Danish and Russian navies.

E. H. S.

Sense of Propeller-Rotation in Twin-screw Ships. Laubeuf.

(Bulletin de l'Association technique maritime, 1903, p. 207.)

This problem has exercised the minds of naval architects from e time of the introduction of twin screws; and the difference of pinion still existing in the French navy is shown in the list of essels submitted. The Author believes that, both as regards cility of manœuvring and economy of power, the best results are btained when the screws are "supra-divergent," that is, turn in ich a sense, that, when viewed from behind, the starboard screw rns in the clockwise sense, and the port screw in the reverse nse. When a ship has but one screw, if this rotate clockwise, ere is a tendency in the ship (for reasons which the Author iggests) to fall off to port, and vice versa. Consequently, if e port screw be stopped, in order to turn the vessel more uickly, the starboard screw causes the ship to turn to port, rst, by reason of the couple due to the thrust multiplied into its centricity, and second, by reason of its own rotation; whereas, hen the screws are "supra-convergent," that is, rotate in the pposite sense to that in the former case, the turning effect of the uple is opposed to that due to the sense of rotation of the ropeller. Further, the Author attempts to demonstrate an crease of efficiency on theoretical grounds, and states that, in his pinion, comparative tests show a distinctly greater disturbance the water when the screws are supra-convergent than when they e supra-divergent, indicating loss of efficiency. Then follow tails of four vessels, whose hulls are identical, the propellers of e pair being supra-convergent, and of the other pair supra-divergent, other conditions being closely comparable. In the former se the mean speed of the two ships was 25·75 knots, and in the

latter case 27·25 knots, showing a difference of 1·5 knot in favour of the latter.

Although the difference in point of efficiency is of little importance in the case of vessels having three propellers, because the lateral screws are farther from the hull and from each other, the Author considers that the advantage in manœuvring is sufficient to justify the adoption of supra-divergent screws, contrary to the practice of the most recent French designers.

E. H. S.

The Submarine Boat "Protector."

(The Engineer, 20 November, 1903, p. 502.)

It is claimed for the "Protector" that, in submerging trim, with the top of the conning-tower awash, and with the sighting-hood still free, she has a reserve buoyancy of 500 lbs., and that it is practicable to submerge her by hydroplanes with a reserve buoyancy of 1,000 lbs. As additional means of safety there is a 5-ton detachable keel of cast-iron, which can be instantly released; also the ballast-tanks are arranged to be emptied automatically by air-pressure at a given depth, or they may be emptied by electrical pumps or by hand; also two anchor-weights may be released.

The complement of the boat consists of eight persons, and it is said that it can be submerged for more than 2 hours without inconvenience. The main hull is calculated to withstand a pressure of 150 feet of water. The vessel is brought from ordinary cruising trim to decks awash by filling the superstructure of the hull with water in about 12 minutes, and in a few more minutes she can be completely submerged by filling the ballast-tanks. An omniscope is fitted for steering when just below the surface. The motive-power is both gasoline and electricity. The two gasoline-engines have four cylinders of the four-cycle type, arranged to give an impulse every stroke. Each engine is of 120 HP. The storage-batteries are of the Gould type, the output being 100 HP. for 3 hours. The boat has twin screws of the reversing type; to each shaft is coupled one gasoline-engine and one motor. The engines can draw air through the omniscope when just submerged, and exhaust under the surface. This is said to increase the radius of action in the submerged condition from 40 miles to 200 miles, at low speed. With the gasoline-engines alone the boat makes 8 knots, and with the motors as well 10 knots, and submerged, under electrical propulsion, 7 knots.

The "Protector" has three torpedo-tubes, one on either side of the bow and one astern.

The hydroplanes, two on either side amidships, are flat rectangular paddles of oak, pivoted in the centre, and tied together by a system of cranks and shafting. With a uniform

peed the depth of submergence is dependent upon the inclina-ion of the hydroplanes.

A horizontal rudder enables the trim to be corrected under water vithout recourse to the ballast tanks.

A. W. B.

Petrol-Motors for Fishing-Vessels. C. Birault.

(Le Génie Civil, vol. xliii., 1903, p. 423.)

The Author describes the application of petrol-motors to fishing-oats, and more particularly to the herring-boat "Jean" of Boulogne. The results attained with this boat in its first season ave been so satisfactory that he considers the use of such engines or this purpose will very quickly develop.

He first details the work to be carried out by the engines of ishing-boats, which he divides under four heads:—

(1) Propelling the boat to and from the fishing-grounds.
(2) Letting down and heaving the nets.
(3) Trawling the nets.
(4) Raising and lowering the mast, sails and cargo.

He then describes existing applications of petrol-driven engines or this purpose in France, Denmark and the United States, and inally describes the installation in the "Jean." This boat has a onnage of 209 tons, its length is 36 metres (118 feet), breadth 8·16 netres (26·75 feet), and depth 4·35 metres (14·26 feet), and it ttains a speed of 8·5 knots per hour.

The engines are of the four-cylinder type, and at a speed of 300 evolutions per minute develop 240 HP. Secondary engines of 0 HP. are provided for working the capstan, and also for driving he air-compressors for starting the main engines. The petrol ised is of a heavy type, and the mixture is fired by tube ignition. The consumption of petrol, per horse-power hour, is 350 grammes 18·4 ounces), costing about 0·6*d*.

The motor is provided with a bevel reversing-gear for going stern. Two sections and a plan show the arrangement of the ngine-room, and two views show the reversing-gear. An exterior view is also given of the engines and of the boat itself.

H. I. J.

Artesian-Well at La Butte-aux-Cailles, Paris. Lucien Fournier.

(La Nature, January, 1904, p. 65.)

The sinking of this well, which was commenced on the 5th May, 1866, has, after an interruption of 22 years from 1870 to 1892, just been completed.[1] On the 19th November last the auger reached the

[1] Minutes of Proceedings Inst. C.E., vol. cxlv. p. 410.

greensand and water flowed out in abundance. An account is given of the nature of the operations, with photographs of the machinery and boring-plant. The strata passed through were sand, limestone-breccia and Soissons clay for the first 216·5 feet, then through chalk down to 1,738·8 feet, beneath which the gault clay and greensand were traversed. In 1898 a spring of water was encountered at a depth of 1,875 feet, but the volume was small and boring was continued further into the greensand, where at a depth of 1,910·8 feet a copious spring of water was found, yielding 15·4 gallons per second, say 1,320,000 gallons per diem. The water, which contains iron and sulphur, comes from the Vandeuvre tableland, and rises to a height of 187 feet.

G. R. R.

The Manufacture of Cast-iron Pipes on the Continent.

F. F. M. WIRTZ.

(Tijdschrift van het Koninklijk Instituut van Ingenieurs, 1903–1904, p. 135.)

Ever since the supplies of gas and water were established in Amsterdam and Rotterdam, the cast-iron pipes used for the conduits have been exclusively of English make. The considerable difference in price between English and American or Continental goods of this description suggested the question whether the cheaper article could not be substituted, and in this way conduce to a saving of important amounts to the ratepayers. Before entertaining further proposals in a matter of such importance, the authorities wished to obtain fuller information, and the Author was commissioned to inquire into the practice of manufacture in German, French and Belgian foundries, as all necessary information as to English and American systems and practice were already at the disposition of the responsible engineers. The Author, in his Report, treats of the whole process of manufacture followed in different foundries on the Continent, up to the latest improvements, as also of the different designs and forms of spigots, collars and flanges. As to the question of strengthening by increased thicknesses of metal, like studs, or ribs cast on, he considers that unequal thickness of metal leads to unequal shrinkage in cooling, and the setting-up of unexpected strains, causing defects difficult to detect and leading to dangerous accidents, more than counterbalancing in ultimate cost the saving obtained by less thickness in the pipes generally. As to the iron employed and the tests applied, he finds that whereas on the Continent a breaking stress of 25 kilograms per square millimetre (15·857 tons per square inch) is deemed sufficient, English foundries readily supply metal with a minimum breaking stress of 31·84 kilograms per square millimetre (20 tons per square inch). English pipes, too, although

as a rule heavier, are of better finish and more trustworthy. He concludes, therefore, that it is preferable to continue the employ of English ware, especially having regard to the nature of the soil on which Amsterdam and Rotterdam are built, which gives a very unequal support to long lengths of conduit, and, therefore, calls for a stronger and better pipe than is considered sufficient in cities situated on firmer formations. Numerous drawings illustrate the Paper.

H. S.

Electrolysis of Water-Mains. D. H. MAURY.

(Engineering Record, Nov. 7, 1903, p. 546.)

Richmond, the Virginian capital, appears to have had a good deal of trouble from the electrolysis of its water-mains through stray currents of the electric railways, and the report of his examination, lately issued by the Author, assesses this damage at \$170,000 (£35,020), exclusive of the deterioration of the service-pipes.

The Author examined one hundred and one lines of pipes, having had fifty holes dug for this purpose, and measuring the differences of potential between the mains and the nearest rail, in about sixty places, found them usually to be low, the differences being mostly under 1 volt in localities where the pipe was positive to the rail. The Author thinks the cause of this is to be found, first in the clay soil, which is nearly always moist, and has a very low resistance; and, secondly, in the system of returns used on the railways being better than the average. No definite "danger district," in which the mains were all positive to the rails, was located.

Every pipe which the Author examined was found to be carrying some current, the amount ranging from very small fractions of an ampere to 18 amperes. In every instance, also, the outside of the mains showed evidences of electrolytic injury, rarely very slight and often very serious. No examination was made of the interior of the pipes, but the pitting on the outside of the mains on the positive side of the joints, in districts where the pipes were negative to the earth, the lead compounds in the soil in front of the joints, and several leaks in the joints, indicate the probability of such inside pitting. Well-defined pittings were found in an 8-inch main, laid only 6 weeks before the examination took place.

As a remedy, the Author recommends the adoption of a properly constructed and maintained conduit system, or double-trolley system.

H. A. R.

Self-Purification of Ice. Dr. F. Abba.

(Zeitschrift für Hygiene, vol. xlv., 1903, p. 285.)

It is a well-known fact that water in passing from the fluid to the solid state is subjected to a very marked biological purifying action. It has been shown that impure water loses about 90 per cent. of its bacteria in becoming frozen, and numerous tests by previous experimenters are recorded, in which corresponding results were obtained. The reason generally given for the great decrease in bacteria is that they are acted upon injuriously by the low temperature, but it is stated that Bordoni-Uffreduzzi found that in order to free water from bacteria, temperatures considerably below zero were needed, and since then Belli has proved that certain germs remain unacted upon at the temperature of liquid air (−180° to −190° C.). Although the effect of low temperature may play an important part in this purifying action, the Author believes that the freedom of ice from bacteria is due mainly to the operations of a physical factor, which exercises a purely mechanical influence. He shows that various circumstances tend to discredit the results obtained from natural ice, and he accordingly conducted a set of experiments with artificial ice. By means of solutions of common salt he was able to satisfy himself that sodium chloride is expelled from water in the act of freezing. Several investigators have called attention to the fact that water in becoming ice tends to throw impurities out of solution, and the Author states that he has found that, in a similar way, micro-organisms become eliminated from the network of ice-crystals. The results are given in tables of numerous tests, conducted with artificial ice-blocks, which were composed of a clear transparent external layer of ice and of a snow-like non-transparent centre, the latter being last formed, and much more rich in micro-organisms. He was led from these experiments to the conclusion that the biological self-purification of ice is effected on similar lines to the above-mentioned chemical self-purification, and is due to the tendency of the molecules of water to free themselves from all extraneous substances in the act of freezing.

G. R. R.

Action of Certain Chemical Disinfectants.

Dr. Schumburg.

(Zeitschrift für Hygiene, vol. xlv., 1903, p. 125.)

Reference is made to a controversy with Dr. Schüder[1] respecting the germicide powers of bromine, and the Author states that further exhaustive investigations have proved the accuracy of the

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[1] Minutes of Proceedings Inst. C.E., vol. cxlix. p. 409.

statement by the above-named observer that bromine in a solution of 0·06 per mille was not invariably fatal to cholera vibrios in drinking-water. But, not contented with the establishment of this fact, the Author has gone a step farther than Dr. Schüder in tracing the operation of bromine upon the individual germs, and he was able to prove that only in very rare cases were to be found, here and there, vibrios of cholera which were capable of resisting the action of the above disinfectant. The mode of carrying out these investigations is described, and the results of very numerous tests are given. As the outcome of these experiments, the Author was induced to ascertain how far the most powerful and widely employed disinfectants could be trusted to destroy every germ in an infected sample, and tests of a 1 per mille solution of corrosive sublimate and of a 5 per cent. solution of carbolic acid were carried out on similar lines to the bromine experiments. The results here also were such as to lead the Author to conclude that in neither case could these solutions be relied upon to destroy entirely all the germs, and that disinfection by the action of heat, and perhaps also by means of ozone, was therefore to be preferred to the bromine process. It is stated that since the above disinfectants, which are the most powerful that it is possible to use, are not certain within a short time (say in three-quarters of an hour) to destroy all germs, no chemical mode of disinfection is to be absolutely depended upon, under all circumstances, to prove fatal to the bacteria which are the active agents in the production of diseases.

G. R. R.

Influence of High Pressure upon Micro-Organisms.

G. W. Chlopin and G. Tammann.

(Zeitschrift für Hygiene, vol. xlv., 1903, p. 171.)

Few experiments have hitherto been recorded with reference to the effects of extreme pressure on the biological properties of micro-organisms, but the Authors have been enabled to subject fluids containing a great variety of pure cultures of bacteria and other germs to a pressure of 43,500 lbs. per square inch, or 2,900 atmospheres, and to maintain them under this pressure, which is more than three times as great as that which would be encountered at the utmost ocean depths, for lengthened periods. The results of the tests are recorded in numerous tables, and show the effects of these pressures when applied very gradually, so as to avoid the excessive rise in temperature due to the compression, which might, in extreme cases, have proved injurious to the vitality of the germs. For similar reasons the pressure was also lowered steadily. Both in applying and removing the pressure, the Authors worked in stages of 7,250 lbs. per square inch, applied in 1 minute, with a res

between each stage of 10 to 15 minutes for cooling, or for rise of temperature, while undergoing compression, or vice versa. The tests of these cultures were, in the case of two species of bacteria, carried out upon living animals—guinea-pigs and mice—in all other tests agar- or gelatine-cultures were employed. The Authors state in conclusion that a single rapid exposure to a pressure of 2,900 atmospheres had but very slight influence upon various micro-organisms. If the pressure is rapidly applied and removed for six times in succession, it has a strongly laming effect on the germs, which is indicated by the rendering of the movements more feeble; the impaired capacity for reproduction; the diminution in ability to effect typical reactions, such as putrefaction, and by decreased virulence in inducing disease. The effect of great pressure upon micro-organisms is of a distinctly individual character, and, in respect of such influence, the Authors classify those germs submitted to experiment in three groups, according to their susceptibility.

G. R. R.

Winter Treatment of Sewage-Beds.

(Engineering Record, Nov. 14, 1903, p. 592.)

The successful working of filtration-plants during severe frost, is a very important matter, and the experience gained on some American sewage-disposal works is of general interest.

At Clinton, Mass., five of the filtration-beds are, just before the cold season sets in, prepared in the following way: The surface is first thoroughly cleaned by raking off the scum and a thin layer of gravel; the beds are then furrowed at right angles to the inlet, the furrows being 3 feet 6 inches apart, and about 1 foot 3 inches deep from the top of the ridge; finally three main furrows are made at right angles with those previously constructed, which are intended to act as carriers from the inlet, which is in the middle of one side of the bed. These beds are used only when the temperature of the air is less than 15° above zero. When in use one of the beds receives the total daily flow of 700,000 gallons to 1,200,000 gallons, and as the sewage percolates, the ice, which has gradually formed on the surface, sinks with it until it rests on the top of the furrows, and thus forms a roof protecting the furrow against the action of the frost and allowing the sewage to filter through these parts of the bed. The ice is allowed to remain until the bed receives the next dose, when it is melted by the fresh sewage. Another roof of ice is then formed, and in this way the work of purifying the sewage is carried on during the winter. It is stated that in no case did the thickness of the ice cover exceed 1 inch during the winter 1902–3. In the spring the scum is removed, and the surface of the beds is restored to a uniform level. When the temperature is above that previously stated, fourteen unfurrowed beds are used, each application of sewage to these lasting 120 minutes to 150

minutes, against 60 minutes to 90 minutes in summer. This is done with a view to thaw the surface and to melt any ice which may have formed.

Further interesting methods of sewage-treatment during the winter are reported from Ames, Iowa, Altoona, Pa., Meriden, Conn., Worcester, Mass., and Woonsocket, R.T., all of which are said to have given good results.

H. A. R.

Disinfection of Sewage-Water, with Simultaneous Purification.

Dr. DUNBAR and Dr. KORN.

(Gesundheits-Ingenieur, 20 January, 1904, p. 17.)

Disinfection of sewage was formerly held to be synonymous with deodorization, and when substances were added to the fouled water which concealed or removed the smell, the treatment was termed a disinfecting process. Later it was usual to speak of disinfection as being identical with purification; but now all of these terms have distinct meanings, and they convey wholly different ideas. The problem in sewage-treatment is generally to effect the purification of the fouled liquid, that is, to free it from dissolved and suspended matters which are capable of causing putrefaction. Only in very few instances is there any necessity for disinfection or for deodorization. The process of disinfection must also not be confounded with sterilization, which involves the total destruction of all germs capable of further development; whereas disinfection need prove fatal only to a relatively small portion of the germs present, and in general only to those which are the active causes of certain infectious diseases. It would be almost impossible to sterilize sewage-water, and it would be of little use to attempt to do so. Until about 10 years ago, it was considered quite a feasible task to disinfect town sewage, but Dunbar and his pupils have shown that the destruction of even the bacilli of typhoid fever is practically out of the question, by means of the lime process, and in fact, that chloride of lime must be employed in order to free the sewage from these germs.

The purification of sewage and its disinfection not only imply, as already stated, two different ideas, but they involve as a rule, also two totally dissimilar aims. The Authors explain in detail what is involved in each case. It is shown that while certain substances used for sewage-disinfection may have a serious influence upon the working of the biological system of treatment, in that they affect the action of the filter-beds, this is not the case when chloride of lime is employed, and water which contains a considerable excess of free chlorine may pass through the filte beds for many months without impairing their efficiency. Cc rosive sublimate and carbolic acid, on the other hand, at on

suppress the biological action, and when these disinfectants are used, it becomes necessary to neutralize the water before passing it on to the filter. The results are given of a series of experiments which establish this important fact with regard to chloride of lime, when this substance was used in sufficient quantities, not only to destroy the typhoid bacilli, but also the coli bacteria, which are slightly more resistant.

G. R. R.

High-Pressure Gas-Distribution by Gas-Power.

(Electrical World and Engineer, N.Y., vol. xliii., 1904, p. 239.)

A gas-power installation is now under construction for supplying the whole area of the city of St. Louis, approximately 65 square miles in extent. To serve the outlying districts of this area by low-pressure feeders from the centre, or by medium-sized feeders from the main holder to auxiliary holders in the centre of each district, would involve a very large expenditure on construction, and a high-pressure system has therefore been adopted. The pressures to be employed are approximately 5 lbs. per square inch for the medium-pressure feeders, which are of cast iron, and 20 lbs. to 80 lbs. per square inch for the high-pressure suburban feeders, which are of iron pipe with screwed fittings. The gas pressure will be supplied by a Connersville blower direct-driven by a 300-HP. Westinghouse horizontal gas-engine, using electric ignition and taking its supply of gas direct from the ordinary lighting mains. The engine is controlled by an automatic pressure-governor which adjusts the speed in direct proportion to the demand for gas. This control is so sensitive that the variation in pressure will not exceed 8 ounces for a 50 per cent. range in output of gas. Full details of the system will be published when the construction is completed.

W. C. H.

The Declination of the Magnetic Needle in Central Europe.

J. B. Messerschmitt.

(Zeitschrift für Vermessungswesen, 1903, p. 681.)

In Germany, since the exhaustive researches carried out by Lamont 50 years ago, little progress was made in the study of terrestrial magnetism until in 1878 a magnetic observatory was erected at Wilhelmshaven to meet the requirements of the navy. Ten years later, the magnetic observatory at Potsdam followed, and in 1898 that at Munich. At the present time, therefore, there are three such observatories in Germany, Besides these observatories proper,

the declination has been regularly followed for mine-surveying purposes for many years at Clausthal, at Freiberg in Saxony, at Schneeberg in Saxony, and during the past 10 years at Bochum, at Beuthen in Silesia and at Hermsdorf, near Breslau. At some of these places recording apparatus has been installed. In Austria magnetic observations have had to be abandoned at Vienna, owing to the influence of the electric tramways, so that the only fully-equipped observatory is that at Pola. These few localities do not suffice to permit the course of the magnetic curves in Central Europe to be followed with certainty; and magnetic surveys are necessary. Many incomplete surveys of the kind have been made, and recently the Potsdam authorities have made a magnetic survey at 250 points in North Germany which connects with a survey at 88 stations in Wurtemburg. The remainder of Germany will be dealt with in a similar way, and the results will, it is hoped, shortly be published. In the meantime the Author gives a table showing the declination calculated for the year 1905 for latitudes of 46° to 55° and for longitudes of 5° 20′ to 22° 20′ east of Greenwich. The annual decrease of the declination in Germany 50 years ago was 7′ to 8′, and since then it has lessened considerably, so that at the present time it may be taken at 5′.

B. H. B.

Action of Light on the Rate of Formation of Accumulators.

D. Tommasi.

(L'Électricien, 1904, p. 89.)

The Author had frequently observed that in an accumulator a negative plate exposed to the light is formed more quickly than one which is in darkness, no matter what be the nature of the active material contained in the plates, the density of the sulphuric acid acting as electrolyte, or the temperature working; and in the present short Paper he gives the results of some experiments expressly undertaken to investigate this phenomenon further, and to find the exact part played by light in the reduction of the active material of the negative plates into spongy lead. By observing what took place in two identical accumulators, each having two positive and three negative plates, and one being exposed to daylight while the other was carefully screened from all light, the Author concluded that in an accumulator, other things being equal, the negative plates are formed more rapidly in light than in darkness. Examining next in a similar fashion the effect of light on the positive plates, he found this to be the inverse of the other case; positive plates are formed more rapidly in darkness than in light. The capacity of accumulators is sensibly the same whether they were "formed" in the light or in darkness.

W. C. H.

Temperature of Flames. C. Téry.

(Comptes Rendus, vol. cxxxvii., 1903, p. 909.)

The ordinary experimental method of determining the temperature of a flame consists in placing a small solid body in the flame and determining the temperature of that body, proceeding upon the assumption that it takes the actual temperature of the hot gases by which it is surrounded. The body may be a thermo-electric junction, whose temperature is then readily obtained from the value of the electric current created in the circuit. The Author points out that this method is open to objection, as there are various sources of error—*e.g.*, conductivity and radiation losses, and the effect of the velocity of the flow of gases in the flame—for which it is very difficult to make proper allowance. He, therefore, has devised another method, which does not involve the introduction of a solid body into the flame, but which consists, in principle, in producing the reversal of a metallic line in the spectrum given by rays from a solid body raised to a suitable temperature. The Author chooses as the luminous solid body an incandescent filament in a glow-lamp, and the rays from this source are made to pass through the flame, which is supplied with sodium. By means of a lens an image of the filament is made to fall on the slit of a spectroscope, so that there is produced the continuous spectrum of the carbon crossed by the sodium D-line. The Author has found it possible, with all the flames he has examined, by varying the temperature of the filament, to cause a reversal of the D-line, and at the moment at which this line disappears, passing from bright to dark, the temperatures of solid and flame are equal. The temperature of the filament is measured by a pyrometric method. The Author gives the results of his measurements of the temperatures of various flames by this process. In conclusion, he points out two hypotheses, the adoption of which is involved in the use of his process, and comments upon their validity.

W. C. H.

The Osmium Lamp. L. Lombardi.

(Elektrotechnische Zeitschrift, 1904, p. 41.)

The Author discusses the mathematics of the osmium lamp as regards its temperature and light emission, and finds that the temperature of the filament and the economy of the lamp can be calculated according to H. F. Weber's formula for carbon lamps, and that the results obtained are in excellent agreement with practice. Although the economy of the osmium lamp is about nine times to twelve times that of the carbon lamp, the remarkable result is obtained, that its temperature is only 1,435° C. (2,615° F.),

s against 1,570° C. (2,858° F.) *i.e.* about 135° C. (245° F.) lower. The Author therefore considers it probable that a common nbstance of high melting-point may be discovered, possessing an ncreased power for the emission of light.

L. F. G.

Swiss Motor-generators for the Stockholm Electricity Works.

(Schweizerische Bauzeitung, vol. xlii., 1903, p. 163.)

The motor-generators referred to were built by the Maschinen-'abrik Oerlikon for the Stockholm electricity works, to transform three-phase current at 6,000 volts and 25 periods into direct-current of different potentials—some for lighting and some for ramway service. The motors are of the asynchronous type with tarting resistance upon the rotors. The sets are of the following ypes: I.—500 kilowatts running at 375 revolutions per minute or direct current of 440 volts to 600 volts; II.—500 kilowatts at 300 revolutions for 220 volts to 300 volts; III.—250 kilowatts at 500 revolutions for 440 volts to 600 volts; IV.—65 kilowatts at 500 revolutions for 440 volts to 600 volts.

Elaborate tests were made upon these machines, and the results are given in great detail. The Author points out the great difficulty of testing such sets accurately for efficiency, as on the three-phase side three voltmeters and three ammeters must be used, and instantaneous readings of all must be taken simultaneously; also, readings must be taken of a voltmeter and ammeter on the direct-current side, and it has been found that only in very rare cases are the three phases symmetrical, and small variations from symmetry affect the measurements greatly. The tests of type I. show that at full load the efficiency of the motor was 95·2 per cent., and that of the dynamo 95·5 per cent. at 440 volts, and 94 per cent. at 600 volts. For type II. the motor gave at full load an efficiency of 95 per cent., and the dynamo 95 per cent. at 220 volts and 94·5 per cent. at 300 volts. For type III. the best efficiency was at three-quarter load, and was 95 per cent. for the motor and 94·9 per cent. for the dynamo at full load. For type IV. the motor gave 93 per cent. and the dynamo 92·5 per cent. All the losses are separately accounted for, and all the figures are plotted in curves. The rise in temperature at full load is in all cases very low. It is stated that these tabulated results accord remarkably well with the previously calculated values. The original contains sixteen illustrations.

E. R. D.

Some German Industrial Laboratories. A. Granger.

(Bulletin de la Société d'Encouragement pour l'Industrie Nationale, December, 1903, p. 715.)

This is an account of the Laboratory of the Tonindustrie Zeitung, which is a private institution situated in Berlin, of the Versuchs-Anstalt at Charlottenburg and of the Material-Prüfungs Anstalt at Nuremberg; the two last are conducted as State institutions by the German and the Bavarian Governments respectively. The first of these laboratories, established by Prof. Seger and Dr. Aron, is now managed by Mr. Cramer, with Drs. Hecht and Möckler, who also edit the *Tonindustrie Zeitung*, which is the official organ of the Union of the Clay, Cement and Lime Industries, and of a number of other trade associations, having here in many cases their offices and local habitat. Plans of the institution are given, together with descriptions of the various instruments employed for testing and for other researches. Numerous illustrations are appended of the muffle furnaces, clay-washing apparatus, instruments for ascertaining the plasticity of clays, gas-analysing, etc. The testing-machinery for cements is explained by the aid of figures and diagrams, and some account is given of the mode of carrying on the different classes of experiments. The working of the Versuchs-Anstalt at Charlottenburg, which has been specially equipped for the study of certain materials used in construction, paper and textiles, oils and fatty matters and metals, is fully explained with illustrations of typical apparatus; a price-list is appended, indicating the fixed tariff for carrying out the various tests. The Material-Prüfungs-Anstalt at Nüremberg, of which an interior view is given, is similarly described, and it is explained that this is not merely a testing-station, but that the authorities undertake to advise on various technical matters submitted to them. In conclusion, brief reference is made to the Royal Chemisch-Technische Versuchs-Anstalt at Berlin.

G. R. R.

Engineering Laboratory at the Zürich Polytechnicum.

(Schweizerische Bauzeitung, vol. xlii., 1903, p. 187. Figs.)

The present engineering laboratory of the Polytechnicum at Zürich was built under an act of the Swiss Parliament of the 2nd July, 1897, and forms part of the large mechanical drawing building. It was opened for use during the summer of 1900, and is divided into the thermodynamic, hydraulic and electric departments. The entire building was designed by Professor Recordon, and detailed plans of the laboratory are given, which prove it to be one of the finest in the world.

The thermodynamic department is described by Prof. Dr. A. Stodola; the principal engine is a triple compound horizontal steam-engine, with cylinders having diameters of 9·4 inches, 14·7 inches and 23·5 inches, with a stroke of 27·5 inches, and running at 100 revolutions per minute. The high- and low-pressure cylinders and the shaft and fly-wheel were built by Messrs. Sulzer Brothers, of Winterthur, and the intermediate cylinders by Messrs. Escher, Wyss & Co., and it drives a direct-current dynamo of 100 HP. and also a 50-HP. polyphase dynamo; a detailed description of the engine is given. There is also a vertical compound steam-engine, built by Messrs. Escher, Wyss & Co., to work at 300 lbs. per square inch, and running at 250 revolutions per minute; the cylinders are respectively 8·25 inches and 15 inches in diameter with 11·8 inches stroke. The large engine is fitted with a special hydraulic dynamometer by Amsler-Laffon, and both engines can be worked condensing. There is also a special balanced steam-engine designed by Mr. C. L. Brown. Near the engine stands a 10-HP. gas-engine by Messrs. Escher, Wyss & Co., running at 220 revolutions per minute, and the compression can easily be altered as desired; there is also a Deutz 5-HP. gas-engine and 5-HP. petrol-engine, and a 5-HP. de Laval turbine, and for the latter a jet condenser is used; adjoining it is a freezing-machine by Messrs. Escher, Wyss & Co.

In the boiler-house there is a cylindrical boiler by a Basle firm, and one by the Swiss locomotive works, and also a Niclausse boiler and a vertical boiler, all working at 180 lbs. per square inch except the Niclausse, which works at 300 lbs. A Von Kowitzke smoke-consuming apparatus, a Meldrum forced-draught grate, and a von Munckner moving grate are used. There are also a Schwoerer superheater and Worthington and other feed-pumps. Besides these main machines there is a quantity of smaller apparatus and a number of machine-tools. The building is very large and lofty, and the Author describes the different classes of experiments which are made during the teaching courses. No care nor expense seems to have been spared to make the laboratory as widely useful as possible. E. R. D.

Law Governing the Disruptive Strength of Materials. C. Baur.

(Elektrotechnische Zeitschrift, 1904, p. 7.)

If V is the voltage effecting penetration, *c* a constant, and *d* the thickness of a plate of the material in millimetres; then $V = cd^{\frac{2}{3}}$. The formula has been applied to the results obtained by the Author, by De La Rue and Müller, by Lord Kelvin, by T. Gray, and by the Standardizing Committee of the American Institute of Electrical Engineers, and found to give results of practical value, although in several cases the calculated and observed figures differ by 20 per cent. or more.

The voltage required to pierce a plate of the material 1 millimetre in thickness is called *c*. It can therefore be called the coefficient of disruptive strength, and lies between 2,400 volts and 3,300 volts for metallic electrodes. It is about 58,000 volts for mica, 20,000 volts for paraffin, and 18,000 volts for porcelain.

L. F. G.

Tests of the Strength of various Argentine Timbers.

EMILIO PALACIO.

(Ensayos de Resistencia de Maderas Argentinas, 46 pp. and Tables; also "Revista Technica," Buenos Aires, 1903.)

The Author, who is Professor of Natural Science in the National University of Buenos Aires, disclaims any intention of presenting a complete study of the physical and mechanical properties of all the various kinds of timber trees growing in the Argentine. His experimental researches have been restricted to twenty-two of the timbers which are most commonly used in construction in that country. The test-pieces were obtained in Buenos Aires, and it was impossible to ascertain the precise dates of felling or the exact age of the trees from which the pieces were taken. The specimens were chosen of the largest size which could be treated with the machines in the laboratory of the University, and these machines and the test-pieces themselves, after fracture, are illustrated by photographs.

The tensile tests were made upon specimens 19·685 inches (50 centimetres) long with a cross section 5 centimetres by 2 centimetres, and a Riehlé testing-machine was used which gripped 12 centimetres at each end.

Compression tests were made upon cubes of 5 centimetres, and shearing tests upon sections 5 centimetres by 2 centimetres, or about 1·54 square inch.

Bending tests were made upon specimens 29·4 inches (75 centimetres) long with a cross section 5 centimetres by 5 centimetres, or 3·85 square inches.

The fractures were carefully photographed so that the mode of rupture can readily be seen. It is impossible to usefully abstract the actual results, and the names of timbers are in many cases only locally familiar, but the data must be of value to engineers designing works to be carried out in the native timbers.

The latter half of the pamphlet consists of a full description of the laboratory of the University, and as this is well illustrated it affords a proof of the satisfactory provision made for teaching this branch of natural science.

E. R. D.

Manufacture of Portland Cement. A. MOREL.

(Le Génie Civil, vol. xliv., 1903, p. 56 *et seq.*)

A short history of the use of various cements is first given, after which the Author proceeds to describe the methods of preparing an artificial Portland cement, and, in order to render his remarks clearer, he divides the manufacture under three heads: (1) The preparation of the "slurry"; (2) the burning; and (3) the grinding. The first of these he sub-divides under the headings of (*a*) the wet process; (*b*) the dry process; but this portion of the article contains nothing which is not generally known.

As regards the burning, the defects of intermittent kilns are pointed out, and it is shown that certain of these are removed by the adoption of the Dietsch kiln, but that a greater advance was made by the introduction of the rotary kiln, of which a very complete account is given. Three forms of this kiln are described: the German, the Danish, and the American, all of which consist essentially of a large tube lined with fire-brick and capable of being rotated about its axis, which is inclined at a small angle to the horizontal. The unburnt cement is fed in at the top end in pieces not larger than a walnut, and it is met by a fierce flame produced by the burning of coal reduced to a very fine powder and blown in by a jet of hot air. The importance of grinding this coal-dust very finely is insisted upon, and it is mentioned that a tube finishing-mill is used to effect this object. The Author advocates the use of the rotary kiln on the ground that the product is more regularly burnt and that the cost is diminished. The ball-mill and the tube finishing-mill are described, and it is pointed out that economy in grinding results from breaking up the lumps in one machine, grinding the product to coarse powder in a second, and finally pulverising in the tube mill, rather than from the older process, where the large lumps were fed direct into the mill-stones, which completed the pulverization.

A digest is added, showing that with modern plant the saving to be effected is no less than 6*s.* 1*d.* per ton of finished cement. Of this amount the saving in fuel is 2*s.* 5*d.*; in steam, 5*d.*; in labour, 2*s.* 5*d.*; and in maintenance, 10*d.* The text is illustrated by numerous sketches, and the article concludes with a table giving the cost of erecting a factory capable of producing 25,000 tons of cement per annum.

I. C. B.

INDEX

TO THE

MINUTES OF PROCEEDINGS,

1903–1904.—Part II.

N.B.—Titles in italics refer to Original Papers, and those selected for printing only are further distinguished by the suffix "(S.)" or ("St."), the latter denoting Students' Papers. Abstracted Papers are not so indicated.

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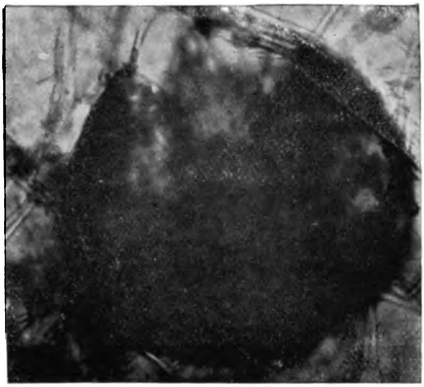
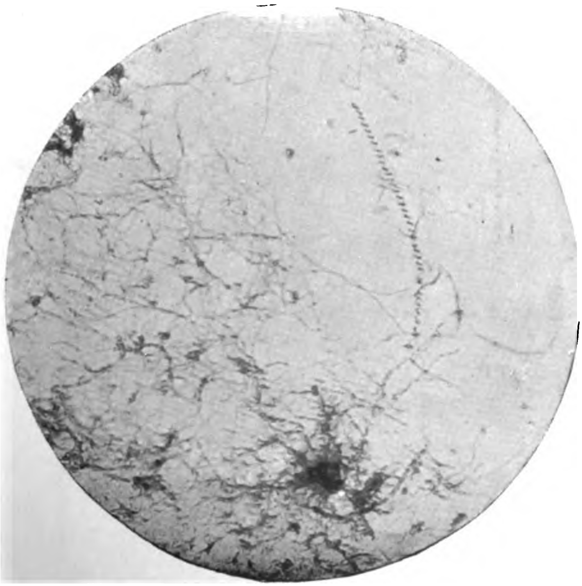
FIG. 21.

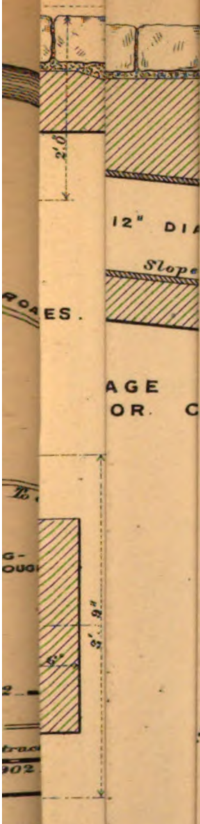


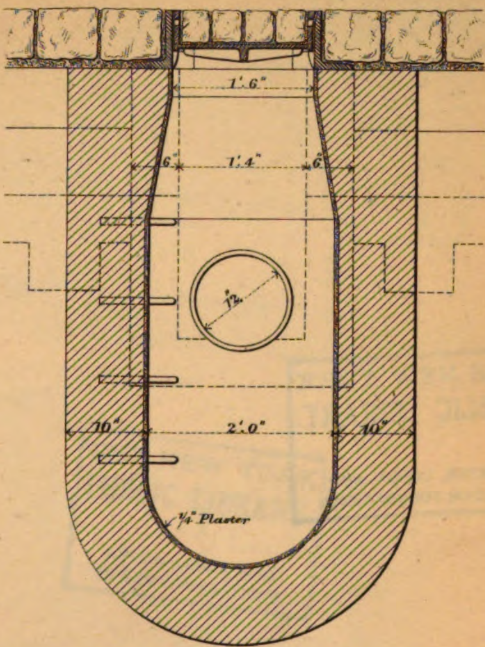
FRESHWATER SPONGE FROM WATER No. 9.

FIG. 20.



JELLY DEVELOPING INTO SLIME.





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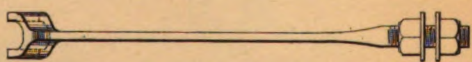
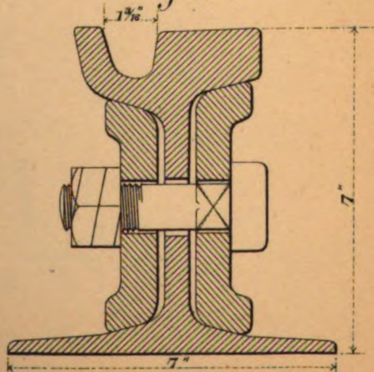


YOKE TIE-BAR.

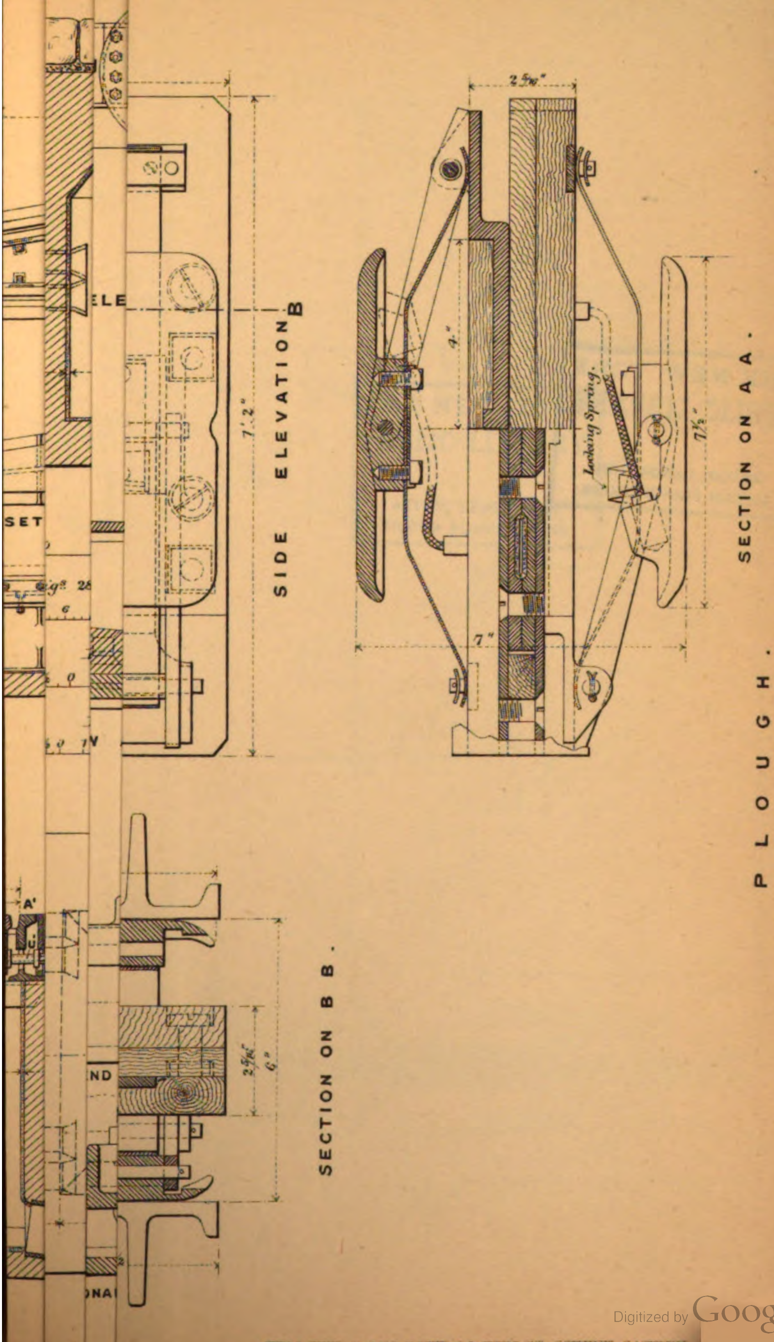
Fig: 18.



INTERNAIL. TRACK-RAIL AT SHARP CURVES

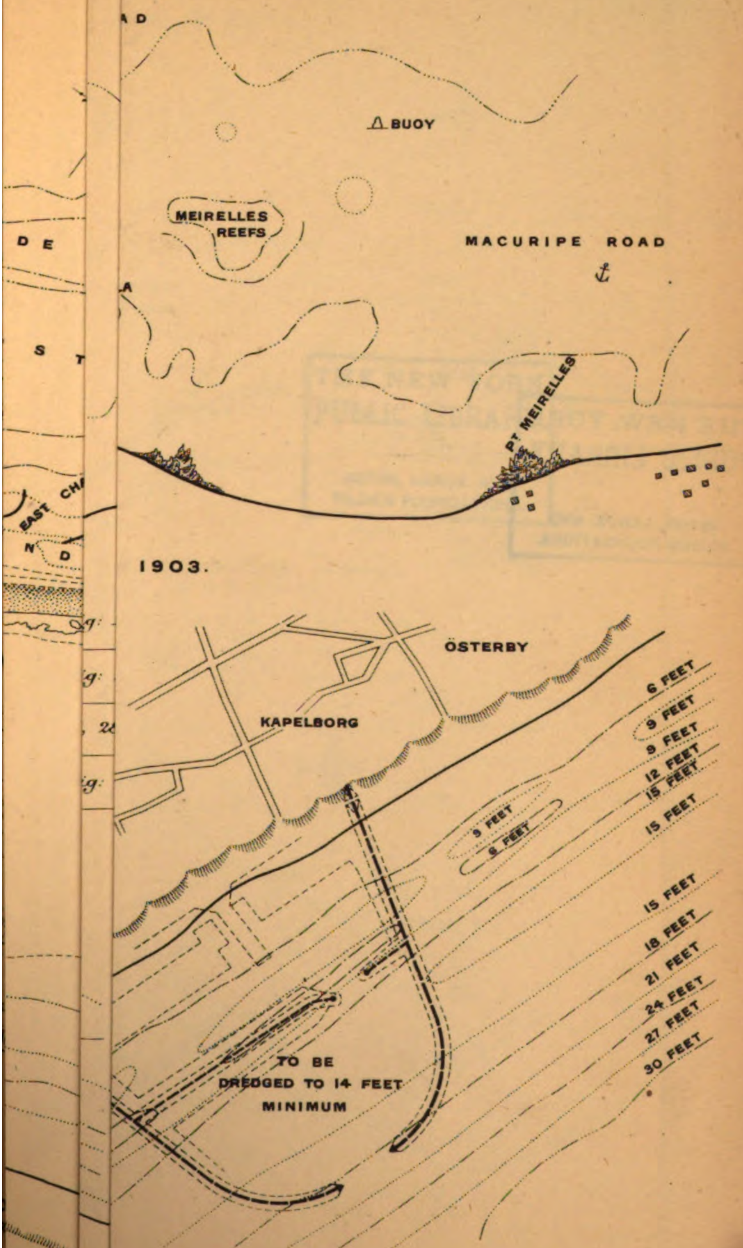
THOS KELL & SON, LITH. 40 KING ST COVENT GARD

PLATE 3.

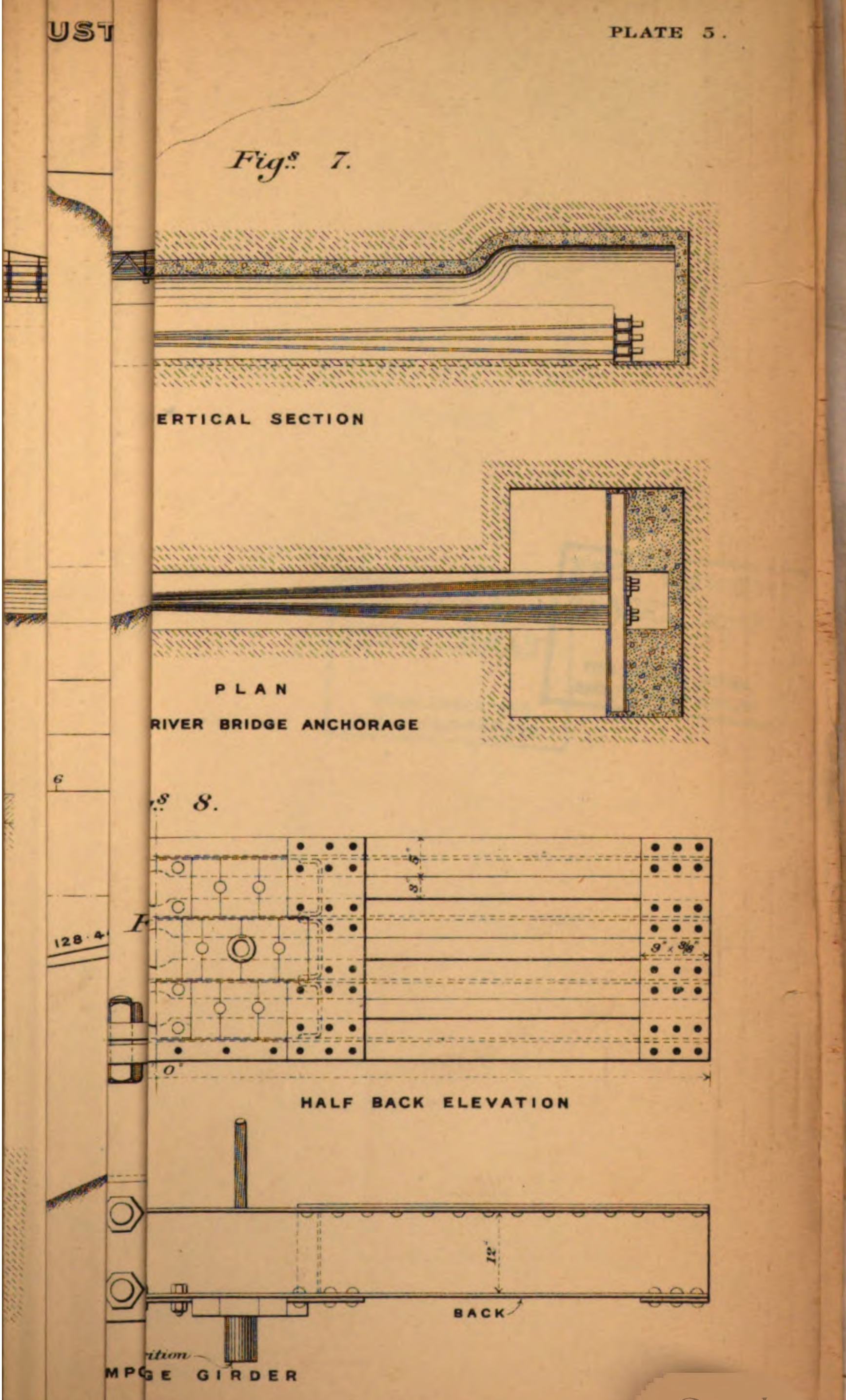


THOS KELL & SON LITH. 40 KING ST COVENT GARDEN.

PLATE 4.



IV KAGEN, DENMARK.
CTED FISHERY HARBOUR.



THOS KELL & SON. LITH, 40 KING ST. COV

PLATE 6.

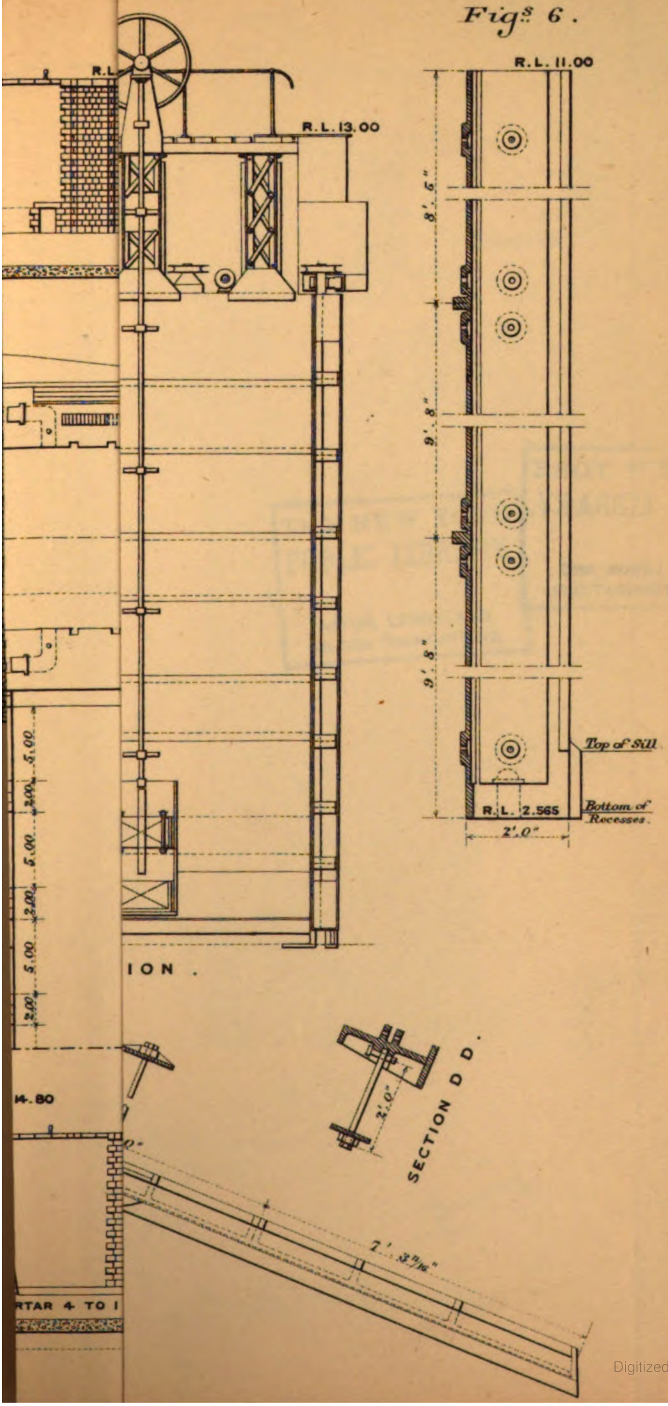
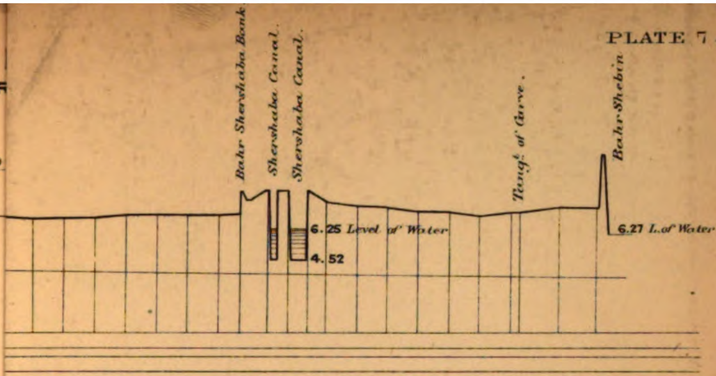
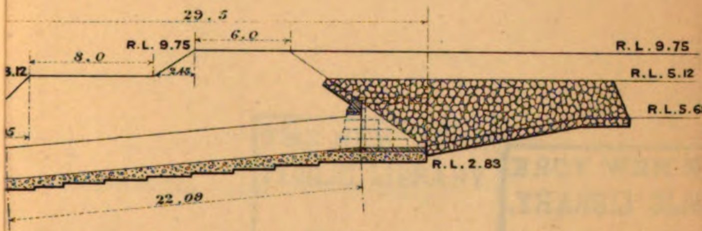
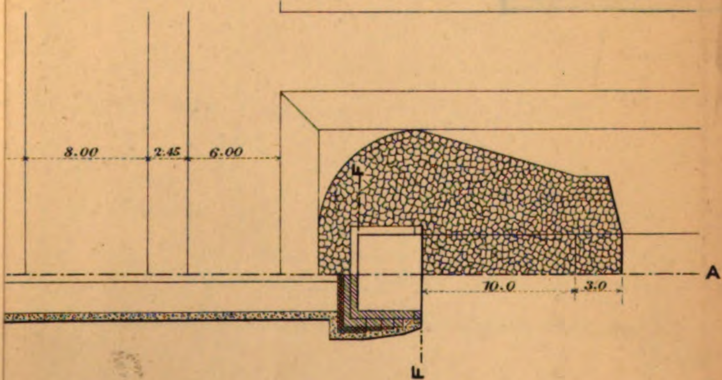

Figs 6.
R.L. 11.00
8' 6"
9' 8"
9' 8"
Top of Sill
R.L. 2.565
Bottom of Recesses.
2' 0"
R.L. 13.00
R.L.
ION.
5.00
2.00
5.00
2.00
5.00
2.00
14.80
RTAR 4 TO 1
2' 0"
SECTION D D.
7' 3 7/16"

PLATE 7.





SECTION B B.



SCALES

Fig^s 7, 9 (Vertical) and 10 ..... 1 Inch = 40 Feet.

5 0 10 20 30 Metres.

10 5 0 10 20 30 40 50 100 Feet.

Fig: 9 (Horizontal) ..... 1 Inch = 4000 Feet.

500 0 1000 2000 3000 Metres.

500 0 5000 10,000 Feet.

Fig: 8 ..... 1 Inch = 80 Feet.

10 5 0 10 20 30 40 50 Metres.

10 5 0 50 100 200 Feet.

SEEN IN LONGITUDINAL SECTION.
N 250 DIAMETERS.

FIG. 4.

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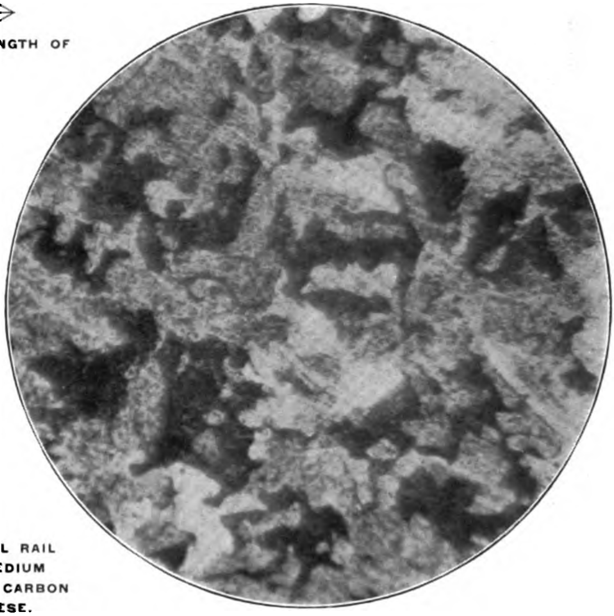
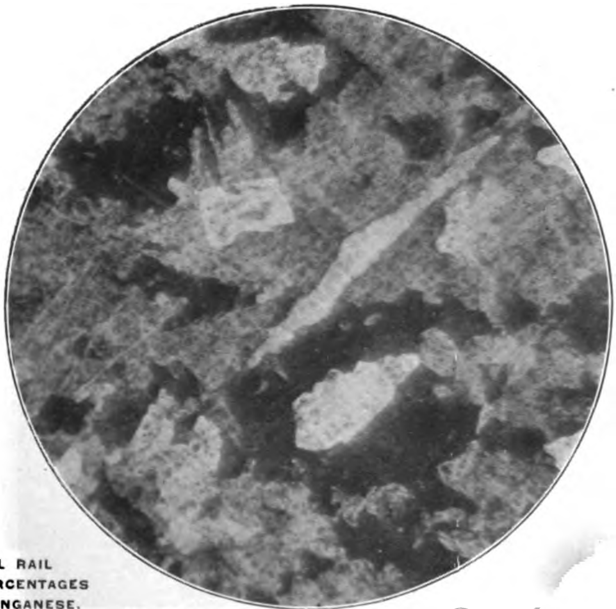
N OF LENGTH OF
RAIL.



ER STEEL RAIL
NING MEDIUM
AGES OF CARBON
MANGANESE.
IDEX No. 1437.

AFTER ANNEALING AT 850°C.

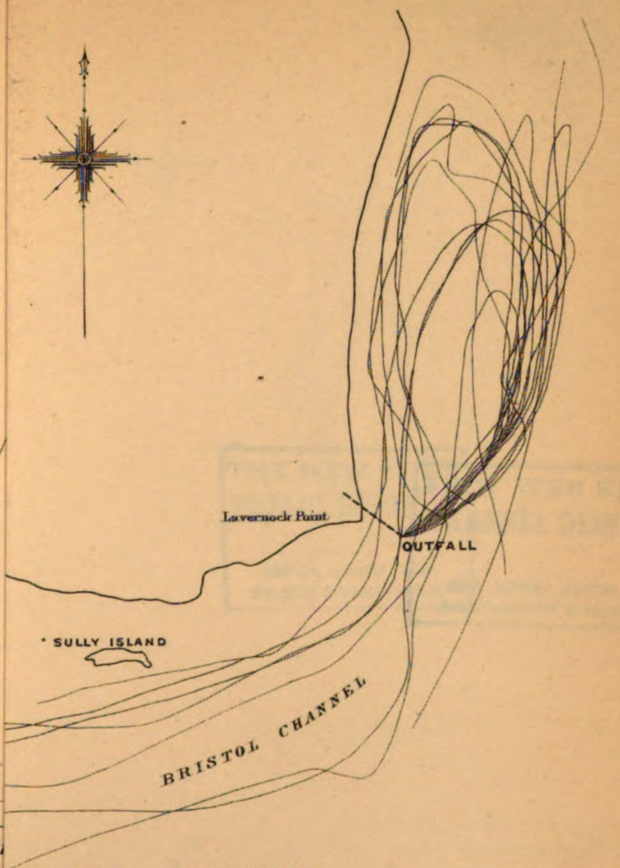
FIG. 6.



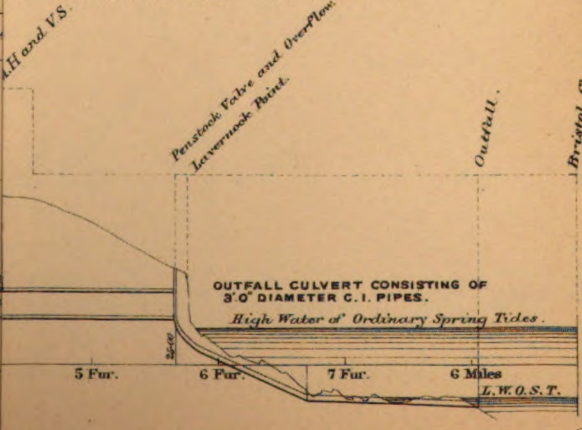
ER STEEL RAIL
HIGH PERCENTAGES
AND MANGANESE.
DEX No. 1667.

AFTER ANNEALING AT 850°C.

PLATE 9.



TIDE GAUGINGS
WO HOURS BEFORE HIGH WATER.



THOS KELL & SON LITH. 40 KING ST COVENT GARDEN

CHARTER,

SUPPLEMENTAL CHARTERS,

BY-LAWS,

AND

LIST OF MEMBERS

OF

The Institution of Civil Engineers.

ESTABLISHED 2 JANUARY, 1818.—INCORPORATED BY ROYAL CHARTER 3 JUNE, 1828.

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[TELEGRAMS, "INSTITUTION, LONDON." TELEPHONE, "WESTMINSTER 51."]
1904.

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CHARTER.

CHARTER

OF

The Institution of Civil Engineers.

INCORPORATED 3 JUNE, 1828.

GEORGE THE FOURTH, by the Grace of God, of the United Kingdom of Great Britain and Ireland King, Defender of the Faith: To all to whom these Presents shall come, Greeting:

WHEREAS THOMAS TELFORD, of Abingdon Street, in our city of Westminster, Esquire, a Fellow of the Royal Societies of London and Edinburgh, and others of our loving subjects, have formed themselves into a Society for the general advancement of Mechanical Science, and more particularly for promoting the acquisition of that species of knowledge which constitutes the profession of a Civil Engineer, being the art of directing the Great Sources of Power in Nature for the use and convenience of man, as the means of production and of traffic in states both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks, for internal intercourse and exchange, and in the construction of ports, harbours, moles, breakwaters and lighthouses, and in the art of navigation by artificial power for the purposes of commerce, and in the construction and adaptation of machinery, and in the drainage of cities and towns: And have subscribed and collected considerable sums of money for those purposes: And We have been besought to grant to them, and to those who shall hereafter become members of the same Society, our Royal Charter of Incorporation, for the purposes aforesaid: Now KNOW YE, that We, being desirous of encouraging a design so laudable

The nature and object of the Society.

and salutary, of our especial grace, certain knowledge, and mere motion, have willed, granted, and declared: And do by these presents, for us, our heirs and successors, will, grant, and declare, that the said THOMAS TELFORD, and such others of our loving subjects as have formed themselves into, and are now members of the said Society, or who shall at any time hereafter become members thereof, according to such regulations or by-laws as shall be hereafter framed or enacted, shall, by virtue of these presents, be the members of, and form one Body Politic and Corporate, for the purposes aforesaid, by the name of "THE INSTITUTION OF CIVIL ENGINEERS;" by which name they shall have perpetual succession, and a common seal, with full power and authority to alter, vary, break, and renew the same, at their discretion: and by the same name to sue, and be sued, implead, and be impleaded, answer, and be answered unto, in every court of us, our heirs and successors; and be for ever able and capable in the law, to purchase, receive, possess, and enjoy to them and their successors, any goods and chattels whatsoever, and also be able and capable in the law (notwithstanding the statutes of mortmain) to take, purchase, possess, hold and enjoy to them and their successors, a Hall, and any messuages, lands, tenements, or hereditaments whatsoever, the yearly value of which, including the site of the said Hall, shall not exceed in the whole the sum of one thousand pounds, computing the same respectively at the rack-rent which might have been had or gotten for the same respectively at the time of the purchase or acquisition thereof; and to act in all the concerns of the said body politic and corporate for the purposes aforesaid, as fully and effectually to all intents, effects, constructions, and purposes whatsoever, as any other of our liege subjects, or any other body politic or corporate in our United Kingdom of Great Britain and Ireland, not being under any disability, might do in their respective concerns. And We do hereby grant our especial licence and authority unto all and every person and persons, bodies politic and corporate (otherwise competent), to grant, sell, alien, and convey in mortmain, unto and to the use of the said Society, and their successors, any messuages, lands, tenements, or hereditaments, not exceeding such annual value as aforesaid

Name of the Society.

And our will and pleasure is, and We further grant and declare, that there shall be a General Meeting of the members of the said body politic and corporate, to be held from time to time, as hereinafter mentioned, and that there shall always be a Council, to direct and manage the concerns of the said body politic and corporate; and that the General Meetings and the Council shall have the entire direction and management of the same, in the manner, and subject to the regulations, hereinafter mentioned. But our will and pleasure is, that at all General Meetings, and Meetings of the Council, the majority of the members present, and having a right to vote thereat respectively, shall decide upon the matters propounded at such Meetings, the person presiding therein having, in case of an equality of numbers, a second or casting vote. And We do hereby also will, grant, and declare, that the Council shall consist of a President, four Vice-Presidents, and not more than fifteen, nor less than seven other Members, to be elected out of the Members of the said body politic and corporate; and that the first Members of the Council, exclusive of the President, shall be elected within six calendar months after the date of this our Charter; and that the said THOMAS TELFORD shall be the first President of the said body politic and corporate. And We do hereby further will, grant, and declare, that it shall be lawful for the Members of the said body politic and corporate, hereby established, to hold General Meetings once in the year, or oftener, for the purposes hereinafter mentioned (viz.); That the General Meeting shall choose the President, Vice-Presidents, and other Members of the Council; that the General Meetings shall make and establish such by-laws as they shall deem to be useful and necessary for the regulation of the said body politic and corporate, for the admission of Members, for the management of the estates, goods and business of the said body politic and corporate, and for fixing and determining the manner of electing the President, Vice-Presidents, and other Members of the Council, and the period of their continuance in office; as also of electing and appointing a Treasurer, two Auditors, and two Secretaries, and such other officers, attendants, and servants, as shall be deemed necessary or useful for the said body politic and corporate; and such by-laws

A General Meeting and Council.

The Member presiding at any Meetings shall have a second or casting vote.

Constitution of the Council.

General Meetings.

General Meetings to make by-laws and regulations.

Mode of electing Officers to be defined by by-laws.

By-laws may be altered.

from time to time shall or may alter, vary, or revoke, and shall or may make such new and other by-laws as they shall think most useful and expedient, so that the same be not repugnant to these presents, or to the laws and statutes of this our Realm; and shall and may also enter into any resolution, and make any regulation, respecting any of the affairs and concerns of the said body politic and corporate, that shall be thought necessary and proper. And We further will, grant, and declare, that the Council shall have the sole management of the income and funds of the said body politic and corporate, and also the entire management and superintendence of all the other affairs and concerns thereof; and shall or may, but not inconsistently with, or contrary to the provisions of this our Charter, or any existing by-law, or the laws and statutes of this our Realm, do all such acts and deeds as shall appear to them necessary or essential to be done, for the purpose of carrying into effect the objects and views of the said body politic and corporate. And We further will, grant, and declare, that the whole property of the said body politic and corporate shall be vested, and We do hereby vest the same solely and absolutely in the Members thereof, and that they shall have full power and authority to sell, alienate, charge or otherwise dispose of the same, as they shall think proper; but that no sale, mortgage, incumbrance, or other disposition of any messuages, lands, tenements, or hereditaments, belonging to the said body politic and corporate, shall be made, except with the approbation and concurrence of a General Meeting. And We lastly declare it to be our Royal will and pleasure, that no resolution, or by-law, shall on any account or pretence whatsoever be made by the said body politic and corporate in opposition to the general scope, true intent, and meaning of this our Charter, or the laws or statutes of our Realm; and that if any such rule or by-law shall be made, the same shall be absolutely null and void, to all intents, effects, constructions, and purposes whatsoever. In witness whereof We have caused these our Letters to be made Patent. Witness Ourself at our Palace of Westminster, this third day of June, in the ninth year of our reign.

No by-law to be repugnant to this Charter.

Council to have sole management of the funds.

Property vested in the Members.

No by-laws to be made contrary to the laws of this Realm.

By Writ of Privy Seal. SCOTT.

SUPPLEMENTAL CHARTER, 1887.

SUPPLEMENTAL CHARTER.

3 *August*, 1887.

VICTORIA, by the Grace of God, of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith: To all to whom these presents shall come, Greeting:

WHEREAS the body politic and corporate of THE INSTITUTION OF CIVIL ENGINEERS was incorporated under or by virtue of a certain Charter or Letters Patent bearing date at Westminster the 3rd day of June in the ninth year of the Reign of King George the Fourth, and the said Institution is now regulated and governed by and according to the provisions of the said Charter or Letters Patent, and also by or according to certain by-laws and regulations made by the said Institution: AND WHEREAS by the said Charter or Letters Patent the said Institution has full power and authority *inter alia* to be able and capable in the law (notwithstanding the statutes of mortmain) to take, purchase, possess, hold and enjoy to them and their successors a Hall, and any messuages, lands, tenements or hereditaments whatsoever, the yearly value of which, including the site of the said Hall, shall not exceed in the whole the sum of one thousand pounds, computing the same respectively at the rack-rent which might have been had or gotten for the same respectively at the time of the purchase or acquisition thereof: AND WHEREAS the said Institution presented their humble petition to us, alleging, *inter alia*, as follows:

"At the time the said Charter was granted the number of members of all classes was 156, and the income for that year was £446 16*s.*; the number of members of all classes on the 3rd of June, 1886, was 5,174, and the total annual receipts of the said Institution for the past year were £19,945. The premises now

occupied by the Institution are situate at No. 25 Great George Street, Westminster, and the Institution entered into possession of them at Christmas 1839. The said premises have become and are totally inadequate for the accommodation now required: It is therefore in contemplation to acquire additional property adjoining the said premises for the extension thereof. The powers of the Charter as to holding land have become exhausted, and the Institution are therefore desirous that the yearly value of the property to be held by them should be extended to the sum of £10,000 at the time of purchase."

Therefore the petitioners most humbly supplicated Us to grant Our Royal Charter, enlarging the Charter of Incorporation for the purpose of empowering the Institution to purchase and hold messuages, lands, tenements and hereditaments of a yearly value not exceeding at the time of purchase the sum of £10,000.

Now KNOW YE, that We, taking the premises into Our Royal consideration of Our especial grace, certain knowledge and mere motion, have granted, constituted and appointed, and by these presents for Us, Our heirs and successors, do grant, constitute and appoint as follows, that is to say:—

1. That the powers of The Institution of Civil Engineers notwithstanding the Statutes of Mortmain, to take purchase, possess, hold and enjoy to them and their successors, a Hall, and any messuages, tenements or hereditaments whatsoever, the yearly value whereof was not to exceed the yearly value in the said Charter mentioned, and the powers unto all and every person and persons, bodies politic and corporate (otherwise competent), to grant, sell, alien, and convey in mortmain, unto and to the use of the said Society, and their successors, any messuages, lands, tenements or hereditaments, not exceeding the yearly value therein mentioned, shall be and are hereby extended, so that the yearly value of the Hall, messuages, lands, tenements and hereditaments, acquired or to be acquired

under the said Charter and this Charter, shall not exceed £8,000, computing the same respectively at the rack-rent which might have been had or gotten for the same respectively at the time of the purchase or acquisition thereof: Provided, that such messuages, tenements or hereditaments shall be aliened, taken and held by the said Institution to be used and enjoyed solely for the purposes thereof and not otherwise.

2. And We do hereby, for Us, Our heirs and successors, grant and declare that these Our Letters Patent, or the enrolment or exemplification thereof, shall be in all things valid and effectual in law according to the true intent and meaning of the same, and shall be construed and adjudged in the most favourable and beneficial sense for the best advantage of the said Institution, as well in Our Courts as elsewhere, notwithstanding any recital, misrecital, uncertainty or imperfection in these Our Letters Patent.

In witness whereof We have caused these Our Letters to be made Patent. Witness ourself at Westminster the 3rd day of August, in the fifty-first year of Our Reign.

By Warrant under the Queen's Sign Manual,

MUIR MACKENZIE.

GREAT SEAL
OF THE
UNITED
KINGDOM.

SUPPLEMENTAL CHARTER, 1896.

SUPPLEMENTAL CHARTER.

20 *March*, 1896.

VICTORIA, by the Grace of God, of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith: To all to whom these presents shall come, Greeting:

WHEREAS the body politic and corporate of THE INSTITUTION OF CIVIL ENGINEERS was incorporated under or by virtue of a certain Charter or Letters Patent bearing date at Westminster the 3rd day of June, in the ninth year of the reign of King George the Fourth, and the said Institution is now regulated and governed by and according to the provisions of the said Charter or Letters Patent, and a certain Supplemental Charter or Letters Patent, dated the 3rd day of August, in the fifty-first year of Our reign, and by or according to certain By-laws and regulations made by the said Institution. AND WHEREAS by the said Charter or Letters Patent of the ninth year of the reign of King George the Fourth it is provided (inter alia) that there shall be a General Meeting of the Members of the said body politic and corporate to be held from time to time as therein mentioned, and that there shall always be a Council to direct and manage the concerns of the said body politic and corporate, and that the General Meetings and the Council shall have the entire direction and management of the same in the manner and subject to the regulations therein mentioned, and that at all General Meetings and Meetings of the Council the majority of the members present and having the right to vote thereat respectively shall decide upon the matters propounded at such Meetings, the person presiding therein having, in case of an equality of numbers, a second or casting vote. And that the Council shall consist of a President, four Vice Presidents, and not more than fifteen

nor less than seven other Members, to be elected out of the said body politic and corporate, and that it shall be lawful for the said body politic and corporate to hold General Meetings once in the year or oftener, for the purposes therein mentioned, including (inter alia) that the General Meeting shall choose the President, Vice Presidents, and other Members of the Council, and that the General Meetings shall make and establish such By-laws as they shall deem to be useful and necessary for the regulation of the said body politic and corporate and (inter alia) for fixing and determining the manner of electing the President, Vice Presidents, and other Members of the Council. AND WHEREAS the said recited portions of the Charter of the ninth year of the reign of King George the Fourth were unaffected by the said Supplemental Charter of the fifty-first year of Our reign, and still remain in force. AND WHEREAS the said Institution presented their humble Petition to Us alleging (inter alia) as follows:—

At the time the said Charter of the ninth year of the reign of King George the Fourth was granted, the number of Members of all classes was one hundred and fifty-six; the prescribed number of the Council was sufficient to enable the Institution to place upon the Council an adequate number of representative men having regard to the total number of Members, and the scope of all branches of Engineering science, as then taught and practised throughout the Realm; and the number of Members residing in or near to the Metropolis formed a large proportion of the whole number, and could reasonably be expected personally to attend General Meetings for the purpose of electing a President, Vice Presidents, and other Members of the Council.

On the 2nd day of January, One thousand eight hundred and ninety-six, the number of Members of all classes was Five thousand nine hundred and sixty-nine; the prescribed number of Members of the Council is no longer sufficient to enable the Institution to place on the Council an adequate number of representative

men having regard to the total number of Members, and the scope of all branches of Engineering science, as now taught and practised throughout the Realm; and the number of Members residing in or near the Metropolis now forms a comparatively small portion of the whole number, and a large proportion cannot now be reasonably expected, personally, to attend General Meetings for the purpose of electing a President, Vice Presidents, and other Members of Council. It is desired by the Members of the Institution, and is expedient, that the maximum number of Members of the Council (exclusive of the President and Vice Presidents) should no longer be limited to fifteen, but should be such number as may be from time to time fixed by the By-laws, having regard to the growth and requirements of the Institution, and that in the maximum number there may be included such number (not being more than four), of Past Presidents of the Institution, to be appointed by the Council from time to time in accordance with By-laws to be made in that behalf, to act as Members of the Council together with the President, Vice Presidents, and elected Members of the Council; and that the minimum number of Members of the Council (exclusive of the President and Vice Presidents, but inclusive of any Past Presidents appointed as aforesaid) should be raised from seven to twenty-two; and that the power of taking part in the election of a President, Vice Presidents, and elected Members of Council should not be confined to Members actually present at a General Meeting; and that the Institution should have power to conduct such election by means of ballot or voting papers in such manner as may be from time to time prescribed by By-laws made in accordance with the said Charters.

Therefore the Petitioners most humbly supplicated Us to grant Our Royal Charter for the purpose of enabling the number of Members of the Council of the Institution to be enlarged in manner aforesaid, and for the purpose of enabling

the votes of Members not actually present at a Meeting to be taken into account in the election of the President, Vice Presidents, and other Members of the Council of the Institution.

Now KNOW YE that We, taking the premises into Our Royal consideration, of Our especial grace, certain knowledge and mere motion, Have granted, constituted, and appointed, and by these presents, for Us, Our heirs and successors, Do grant, constitute and appoint in manner following, that is to say:—

THAT, notwithstanding anything in the Charter of the ninth year of the reign of King George the Fourth, incorporating THE INSTITUTION OF CIVIL ENGINEERS, the By-laws of the Institution may from time to time prescribe a maximum number of Members of the Council (other than and exclusive of the President and Vice Presidents) and that from and after the enactment of any such By-law the number of Members of the Council (other than and exclusive of the President and Vice Presidents) shall not be more than the maximum so prescribed, nor less than twenty-two.

THAT, notwithstanding anything in the said Charter, the By-laws of the Institution may from time to time prescribe that a certain number (not being more than four) of the Members of the Council shall be former Presidents of the Institution, to be appointed by the Council from time to time, in accordance with such By-laws, to act as Members of Council together with the President, Vice Presidents, and elected Members of the Council, and so that the Past Presidents so appointed shall, while they hold office under such appointment, be deemed to be members of the Council for the purpose of computing the maximum and minimum number of Members, and for all other purposes.

THAT, notwithstanding anything in the said Charter, the votes of Members not actually present at Meetings at which the election of the President, Vice Presidents, and other Members of the Council (other than Past Presidents appointed under this Our Charter) is propounded, or at which the President, Vice Presidents, and Members (other than as last aforesaid) are chosen, may be taken into account by means of ballot or voting papers or instruments of proxy

as may be prescribed by by-laws from time to time framed for that purpose by the Institution.

THAT the Council, consisting of a President, four Vice Presidents, and not more than the maximum number for the time being prescribed by the By-laws, nor less than twenty-two other Members constituted in accordance with this Our Charter, shall have the direction and management of the concerns of the said body politic and corporate, and the rights and duties conferred on the Council elected out of the said body politic and corporate in accordance with the said Charter of the ninth year of the reign of King George the Fourth.

AND We do hereby, for Us, Our heirs and successors, grant and declare that these Our Letters Patent, or the enrolment or exemplification thereof, shall be in all things valid and effectual in law according to the true intent and meaning of the same, and shall be construed and adjudged in the most favourable and beneficial sense for the best advantage of the said Institution, as well in Our Courts as elsewhere, notwithstanding any recital, misrecital, uncertainty, or imperfection in these Our Letters Patent.

IN WITNESS whereof We have caused these Our Letters to be made Patent. Witness Ourself at Westminster, the twentieth day of March, in the Fifty-ninth year of our reign.

BY WARRANT UNDER THE QUEEN'S SIGN MANUAL.

MUIR MACKENZIE.

GREAT SEAL
OF THE
UNITED
KINGDOM.

BY-LAWS AND REGULATIONS.

BY-LAWS AND REGULATIONS

OF

The Institution of Civil Engineers.

AS AMENDED 20 DECEMBER, 1898.

SECTION I.

OBJECTS.

THE INSTITUTION OF CIVIL ENGINEERS was first established, and has since been incorporated by Royal Charter, for the general advancement of Mechanical Science, and more particularly for promoting the acquisition of that species of knowledge which constitutes the profession of a Civil Engineer.

SECTION II.

CONSTITUTION.

1. THE INSTITUTION OF CIVIL ENGINEERS shall consist of Members, of Associate Members, of Associates entitled to the privileges of Corporate Membership, and of Honorary Members. All such Members, Associate Members, Associates, and Honorary Members may hereafter be referred to as Corporate Members. The Institution may also have attached to it Associates who are not entitled to the privileges of Corporate Membership, and Students.

2. MEMBERS shall comprise every person who, on the 2nd of December, 1878, was on the Register as a Member; and every person thereafter elected or transferred into the class of Members. Every Candidate for election or transfer into the

class of Members shall be more than thirty years of age, and shall come within one of the following conditions:—

He shall have been regularly educated as a Civil Engineer, shall have had subsequent employment for at least five years and shall be actually engaged at the time of his application for election, in responsible situations as Resident Engineer, or otherwise, in some of the branches defined by the Charter as constituting the profession of a Civil Engineer; or,

He shall have practised on his own account in the profession of a Civil Engineer for at least five years, and shall have acquired a considerable degree of eminence in the same.

3. Associate Members shall comprise every person who, being a Civil Engineer by profession, was on the register as an Associate on the 2nd of December, 1878, and every person thereafter elected into the class of Associate Members.

Every candidate for election into the class of Associate Members shall be more than twenty-five years of age,

(*a*) He shall have been regularly educated as a Civil Engineer, shall have passed such examination or examinations as are appointed or are recognized by the Council, and shall be actually engaged at the time of his application for election, in the design or in the construction of such works as are comprised within the profession of a Civil Engineer as defined by the Charter; or,

(*b*), He shall satisfy the Council that he has had a sufficient training, that he has been engaged for at least five years and that he is actually engaged at the time of his application for election, in the design or in the construction of such works as are comprised within the profession of a Civil Engineer as defined by the Charter, and shall furnish a satisfactory Thesis or Paper on a professional subject; or,

(*c*), He shall, whilst complying with either of the foregoing conditions as to training and occupation as set forth in the paragraphs (*a*) and (*b*), afford satisfactory proof to the Council of his fitness for election without either examination or the submission of a Thesis or Paper.

4. Associates entitled to the privileges of Corporate Membership shall comprise every person who, not being a Civil Engineer by profession, was on the Register as an Associate on the 2nd of December, 1878.

5. Associates not entitled to the privileges of Corporate Membership shall be persons who are not Civil Engineers by profession, but whose pursuits constitute branches of Engineering, or who by their connection with Science or the Arts, or otherwise, are qualified to concur with Civil Engineers in the advancement of professional knowledge.

6. Honorary Members shall be either distinguished individuals, who from their position are enabled to render assistance in the prosecution of public works, or persons eminent for science and experience in pursuits connected with the profession of a Civil Engineer, but who are not engaged in the practice of that profession in the United Kingdom or its dependencies.

7. Students shall be persons not under eighteen years of age, who are, or have been, pupils of Corporate Members of the Institution, who have complied with the regulations of Section IV. of these By-Laws, and who have the object or intention of becoming engaged in the design or in the construction of such works as are comprised within the profession of a Civil Engineer as defined by the Charter; and such persons may continue Students until they attain the age of twenty-six years, but not longer.

8. The Officers of the Institution shall be a President, four Vice-Presidents, and other Members of Council to be elected or nominated under the By-Laws, who shall constitute the Council to direct and manage the concerns of the Institution; also two Auditors of Accounts, a Treasurer, and two Secretaries. Such Officers shall be elected or appointed annually in manner hereinafter directed.

9. Any Member, Associate Member, Associate, Honorary Member, or Student, having occasion to designate himself as belonging to the Institution, shall state the class to which he belongs, according to the following abbreviated forms, *viz.* M. Inst. C.E., Assoc. M. Inst. C.E., Assoc. Inst. C.E., Hon. M. Inst. C.E., Stud. Inst. C.E.

Section III.

ELECTION, TRANSFER AND EXPULSION OF MEMBERS, ASSOCIATE MEMBERS, ASSOCIATES AND HONORARY MEMBERS.

1. Any person desirous of being elected a Member, Associate Member, Associate, or Honorary Member, must be proposed and recommended according to the Form A in the Appendix, in which the name, usual residence, and qualifications of the candidate shall be distinctly specified. The proposal must be signed by at least six Corporate Members certifying a personal knowledge of the candidate, and a full conviction of his qualifications, and the candidate must sign the undertaking appended to the Form.

2. The proposal so made, being delivered to the Secretary, shall be submitted to the Council, who shall consider the qualifications specified, and shall in the case of persons required by these By-laws to have passed Examinations appointed or recognised by the Council, or to have furnished Theses or Papers, satisfy themselves that the candidate has passed the necessary examination or examinations, or has furnished the necessary Thesis or Paper. The Council shall determine the class for which the candidate is to be presented for Ballot, and shall specify the same on the proposal. The Chairman of the Meeting of Council which approves, or (after being satisfied as aforesaid) finally approves, the eligibility of a candidate, shall sign the proposal, which shall then be read at the next Ordinary Meeting of the Institution, and be placed in some conspicuous situation until the candidate is balloted for, and six clear days shall elapse between the reading of the proposal and the Ballot.

The Council shall cause to be held examinations for persons desirous of being elected Associate Members, and shall frame regulations for such examinations, defining the times at which they shall be held, the subjects which they shall comprise, and the fees to be paid or deposited by candidates in respect of such examinations; and they may from time to time add to or vary or rescind any of the aforesaid regulations as it may appear to them to be necessary.

The examinations shall be directed by the Council, who shall obtain such assistance as may be necessary from qualified persons to be appointed by them examiners in such subjects as the Council may from time to time determine. The remuneration of such examiners shall be fixed by the Council. The Council may in their discretion permit persons[1] who are not at the time candidates for election to present themselves for examination, and if they pass such examination the Council may exempt them (wholly or partially) from further examination if they subsequently apply for election. After each examination held under the direction of the Council a report of the names of those who have passed shall be presented by the examiners to the Council. The Council shall have power to recognize such University degrees and Collegiate or other certificates as after scrutiny they may deem to prove a sufficient standard of attainment in the subjects referred to; and may exempt such graduates or holders of such certificates from passing the aforesaid examinations appointed and directed by the Council.

3. Any person whose proposal has been passed by the Council shall be duly informed of it by a letter from the Secretary.

4. Ballots shall take place at the first Ordinary Meeting of the Institution in the month of December in each year, and at the first Meeting in each ensuing month during the Session, and at the last Meeting but one in the Session. Only Corporate Members have the right of voting.

5. Every candidate shall be declared to be elected unless there be at least one negative vote for every four affirmative votes.

6. In any election a second ballot shall be granted, at the same Meeting, if it be demanded immediately by any three persons present having a right to vote.

7. In case of the non-election of any person balloted for no notice shall be taken thereof on the minutes.

8. The proposal for transferring any person from the class of Associate Members to the class of Members shall be according to Form C in the Appendix. This form being subscribed by at least ten Corporate Members, and delivered to the Secretary, shall be submitted to the Council, who, subject to the conditions

[1] At present such permission is granted only to Students of the Institution.

hereinbefore set forth, may, if they think fit, make the proposed transfer.

9. Any person duly elected a Member, Associate Member, Associate, or Honorary Member, or transferred from one class to another, shall be informed thereof without delay, by a letter, according to the Form D, enclosing a promise (Form E), which promise the person elected or transferred must sign and return to the Secretary, and he must pay the admission fee and annual subscription for the current year (or the increase thereof in case of transfer) within two months after the date of his election or transfer which otherwise shall become void; but the Council may in particular cases extend the time.

10. Every individual elected, and having signed the Form E in the Appendix, and the Register of the Institution, and having likewise made the proper payments, shall receive the diploma of his election. At the first Ordinary Meeting at which he is present, he shall, after having fulfilled the foregoing requirements, be introduced according to the ensuing form: *viz.* the President or Chairman of the Meeting, addressing him by name, shall say, "As President (or as Chairman of this Meeting) "of THE INSTITUTION OF CIVIL ENGINEERS, I introduce Mr. "A. B. as a Member, Associate Member, Associate, or Honorary Member (as the case may be)."

11. The Council shall have the right, by a majority of two-thirds of those present at a meeting of the Council, to expel from the Institution any Member, Associate Member or Associate who may be convicted, by a competent tribunal, of felony, embezzlement, larceny, or misdemeanour, or other offence which, in the opinion of the Council, renders him unfit to be a member; and in case the Council shall be of opinion that the conduct of any Member, Associate Member or Associate should become the subject of enquiry with a view of ascertaining whether there are grounds for his expulsion, or in case twenty or more Corporate Members shall think fit to draw up and sign a proposal for the expulsion of a Member, Associate Member or Associate on any ground whatever, and shall deliver the same to the Secretary to be laid before the Council for consideration, the Council shall make such enquiry as they deem adequate; and if they do not find sufficient reason for

expulsion no entry of the enquiry shall be made in the Minutes; but if the Council by a majority of at least eleven-twelfths of those present at a Meeting of the Council specially summoned for the purpose and at which at least twelve Members of Council are present, do find good reason for expulsion of the Member, Associate Member or Associate on the ground that he has been guilty of disgraceful conduct in any professional respect they shall cause such person's name to be erased from the Register and thus expel him from the Institution. The Secretary shall give him notice according to Form G in the Appendix, and the Council shall report such erasure at the next Annual General Meeting.

Section IV.

ADMISSION AND PRIVILEGES OF STUDENTS.

1. Upon producing evidence of having passed such examination or examinations in the subjects of general education as may be appointed or recognized by the Council, persons, between the ages of 18 and 25 years, may be admitted as Students by the Council on the recommendation (according to Form B in the Appendix) of the Corporate Members under whom they are, or have been, pupils; and they may remain Students of the Institution, at and during the pleasure of the Council, until they attain the age of twenty-six years, when they shall cease to be Students.

The Council may cause to be held examinations for persons desirous of being admitted Students, and may frame regulations for such examinations, defining the times at which they shall be held, the subjects which they shall comprise, and the fees to be paid or deposited by candidates in respect of such examinations; and the Council may from time to time add to or vary or rescind such of the aforesaid regulations as may appear to them to be necessary, and shall have power to recognize in their discretion University degrees and Collegiate and other certificates in lieu of examinations appointed under the provisions of this Section.

2. Any person admitted as a Student shall be informed thereof by letter (according to the Form F in the Appendix)

stating that the first year's subscription must be paid within two months, otherwise the admission will be void. When the first subscription shall have been paid he shall be entitled to attend the Ordinary Meetings, but not to vote at such Meetings, and to have the use of the Library (subject to such regulations as the Council may from time to time prescribe), as well as to receive a copy of the Minutes of Proceedings relating to each session during which he shall continue to be a Student.

3. Students of the Institution are eligible to compete for the premiums or prizes arising out of the "Miller Fund," and any other funds devoted by the Institution, or by any person or persons, for premiums or prizes for Students.

4. The Council may accord to Students other privileges, but subject to such terms, regulations, and restrictions, as they shall from time to time prescribe.

5. No Student will be allowed to introduce a stranger into the rooms of the Institution.

Section V.

CONTRIBUTIONS TO THE FUNDS.

1. Those Members, Associate Members, Associates, and Students, whose place of business or whose residence is within ten miles of the General Post Office, shall be considered Residents, and those beyond such limits Non-Residents.

2. On change of place of business or of residence, so as to go beyond or come within those limits before each annual contribution becomes due, the amount thereof shall vary accordingly.

3. Each resident Member shall pay four guineas, and each non-resident Member three guineas, per annum.

4 Each resident Associate Member and Associate shall pay three guineas, and each non-resident Associate Member and Associate two guineas and a half, per annum. The subscription for the current year paid by an Associate Member shall, on his transfer to Membership, be taken as in part payment of his subscription as a Member for that year.

5. Each resident Student shall pay two guineas, and each non-resident Student one guinea and a half, per annum. The

subscription for the current year paid by a Student shall on his election to Associate Membership, be taken as in part payment of his subscription as an Associate Member for that year.

6. Every new Member, Associate Member and Associate shall on admission to the Institution pay a fee of ten guineas; but no payment, other than the increased annual subscription, shall be due from an Associate Member on his transfer to Membership.

7. Any Member, Associate Member or Associate, whose subscription is not in arrear, may compound for future annual subscriptions by the payment of sixty guineas. All such compositions shall be invested, and the interest alone shall be appropriated to the current expenditure of the Institution, except by special direction of the Council on the report and recommendation of the Finance Committee.

8. All annual subscriptions are due on the first of January in each year for the year then commencing, and must be paid before the first of April of that year; any Member, Associate Member, Associate, or Student, whose subscription is in arrear shall not be entitled to attend any Meeting or to receive the publications. The subscription of any Member, Associate Member, or Associate, elected at the Ballot in December, shall become due on the first of January next ensuing: and the subscription of any Student admitted in the month of November or December shall become due on the first of January next ensuing.

9. Every individual elected a Member, Associate Member or Associate, and every Student, shall be liable for the payment of his annual subscription, until he has signified to the Secretary, in writing, his desire to resign, having previously paid all arrears, or until he has forfeited his right to remain in, or to be attached to, the Institution.

10. Any person whose subscription is two years in arrear, that is to say, whose arrears and current subscription shall not have been paid on or before the first of April, shall be reported to the Council, who shall direct application to be made to him according to Form H; and in the event of its continuing one month in arrear, after such application, the Council shall have the power, after suitable remonstrance, by letter, in the

D 2

form so provided (Form I), of erasing the name of the defaulter from the Register or lists of the Institution.

11. In the case of any Corporate Member who has been long distinguished in his professional career, but who, from ill health, advanced age, or other sufficient cause, does not continue to carry on a lucrative practice, the Council, if they find good reason for the remission of the annual subscription, may so remit it. Also they may remit any arrears which are due from such an individual; or may accept a collection of books, or drawings, or models, or such other contribution as, in their opinion, under the circumstances of the case, may entitle the person to be enrolled as a Life Subscriber, or to enable him to resume his former rank in the Institution which may have been in abeyance from any particular cause. The Council may, if they find good reason to do so, re-instate, under such conditions as they may see fit, any Member, Associate Member or Associate, whose name has been removed from the Register under the provisions of this Section.

These cases must be considered and reported upon to the Council by a Committee appointed by the Council for the purpose.

Section VI.

CONSTITUTION OF THE COUNCIL.

1. The number of the Council shall be such as the Council in any year may fix for the ensuing year provided that such number shall not be less than twenty-three nor more than thirty-one inclusive in both cases of the President and Vice-Presidents, but exclusive of such of the Past Presidents, if any, as may be appointed by the Council.

The President, the four Vice-Presidents, and other members of the Council (exclusive of Past Presidents, to be appointed by the Council) shall be elected annually, and the Council, when elected for the year, may appoint any number of Past Presidents, not exceeding four, to be members of the Council for the same year.

The year of office for the President, Vice-Presidents and other Members of the Council, shall commence at the com-

mencement of each Session, and the election of the Council at the Annual General Meeting for the ensuing year, and the appointment of other members of the Council for the same year, shall have reference to the next ensuing year of office as hereby defined.

The existing Council shall in all cases continue in office till the commencement of the next Session, notwithstanding that more than a year may have elapsed since the commencement of their year of office.

2. At an Ordinary Meeting at least four weeks before the Annual General Meeting, the Council shall present a list of persons whom they nominate as suitable for the offices of President, Vice-Presidents, and other members of the Council for the ensuing year, exclusive of Past Presidents to be appointed by the Council when elected. The list shall include the names of not less than seven corporate members who have not served on the Council during the current or the preceding year, and the number of names in all shall be at least two in excess of the number of the Council to be elected. The list so presented shall be the balloting list for the annual election on the last Tuesday of the Session.

No person shall be nominated for the office of President more than two years consecutively, and at the expiration of such two years he shall not for a period of three years be eligible to be nominated for that office.

The senior Vice-President in duration of office shall be nominated for President, except he give notice to the Council, at least one month previously, of his intention to decline accepting office.

In case of the decease or resignation of the President, the Council shall be empowered to summon a Special General Meeting of Corporate Members who shall proceed to the nomination and election of a President, the senior Vice-President being nominated as above provided.

3. At the Annual election, each Corporate Member may erase any name or names from the balloting list, and may substitute the name or names of any other person or persons eligible for each respective office; but the number of names on the list, after such erasure or substitution, must be, without the repetition of any of them, the number to be elected to the

respective offices as above enumerated. Those lists which do not accord with these directions shall be rejected by the Scrutineers.

4. At the Ordinary Meeting next before the Annual General Meeting the members shall choose two or more persons as Scrutineers for the purposes of the Ballot. The Balloting List shall immediately after the Ordinary Meeting at which it has been presented by the Council be issued to all members in the United Kingdom, and to any other member residing elsewhere, who may, in writing, request to have the list forwarded to him, and shall be returned to the Secretary, at least three days before the Annual General Meeting, in a closed envelope. The Scrutineers shall open the envelopes and count the votes and report the result at the Annual General Meeting. Any Balloting List on which a member has voted for a number either more or less than one person as President, four persons as Vice-Presidents, and the prescribed number of persons as other elected Members of the Council, shall be rejected by the Scrutineers.

5. The two Auditors shall be elected or appointed by the Annual General Meeting.

6. The Treasurer and Secretaries shall be appointed annually by the Council.

Section VII.

THE PRESIDENT.

The President shall take the chair at all Meetings of the Institution, the Council, and the Committees, at which he is present, and shall regulate and keep order in the proceedings.

Section VIII.

THE VICE-PRESIDENTS.

In the absence of the President, it shall be the duty of the Vice-Presidents to preside in rotation at the Meetings of the Institution, and to regulate and keep order in the proceedings. But in case of the absence of the President and of all the Vice-

Presidents, the Meeting may elect any member of Council, or, in case of their absence, any Corporate Member present, to take the chair at the Meeting.

SECTION IX.

PROCEEDINGS OF THE COUNCIL.

1. The direction and management of the concerns of the Institution are vested in the Council, under the control of the Charter, By-Laws and Regulations, and of all Resolutions of Special General Meetings of Corporate Members, which have been duly summoned and held in accordance with the Charter and By-Laws, when such Resolutions have been duly entered on the Minutes, and signed by the Chairmen of the Meetings.

2. The Council shall meet as often as the business of the Institution may require; and at every Meeting three shall constitute a quorum. The Council may appoint Committees, for special purposes, to report to the Council.

3. All questions shall be decided in the Council by vote; but at the desire, expressed in writing, of any two members present, the determination of any subject shall be postponed to the succeeding Meeting.

4. A statement of the funds of the Institution, and of the receipts and payments during the past year, terminating on the 31st of March, shall be made, under the direction of the Council, and, after having been verified and signed by the Auditors, shall be laid before the Annual General Meeting.

5. The Council shall draw up a yearly Report on the state of the Institution, which shall be read at the Annual General Meeting.

6. It shall be the duty of the Council to adopt every possible means for the advancement of the Institution; to provide for properly conducting the business of the Institution in all cases of emergency, as the death or resignation of officers; and to arrange for the publication of the Papers read at the Meetings, and of such documents as may be calculated to advance professional knowledge.

Section X.

THE TREASURER AND THE TWO AUDITORS.

1. The Treasurer shall be a Banker in the Metropolis, with whom all uninvested money belonging to the Institution shall be deposited by the Council on account and for the use of the Institution.

2. No sum of money payable on account of the Institution, amounting to five pounds and upwards, shall be paid except by order of the Council, signed by the Chairman of the Meeting at which the cheque was ordered, and by two other members of Council, and countersigned by the Secretary.

3. The Auditors shall have access at all reasonable times to the Accounts of the pecuniary transactions of the Institution; and they shall verify and sign the annual statement of the Accounts before it is submitted by the Council to the Annual General Meeting.

Section XI.

THE SECRETARIES.

1. The Secretaries of whom one shall be Honorary, and the other or acting Secretary shall be designated as the Secretary, shall be appointed every year by the Council, at the first Meeting of the Council after the Annual General Meeting.

2. It shall be the duty of the Secretary, under the direction of the Council, to conduct the correspondence of the Institution; to attend all Meetings of the Institution, and of the Council, and of Committees; to take Minutes of the proceedings of such Meetings; to read the Minutes of the preceding Meeting and all communications that may be ordered to be read; to superintend the publication of such Papers as the Council may direct; to have charge of the Library; to direct the collection of the

subscriptions and the preparation of the account of the expenditure of the funds, and to present all accounts to the Council for inspection and approval. He shall also engage and be responsible for all persons employed under him, and shall generally conduct the ordinary business of the Institution.

Section XII.

THE SESSIONS AND MEETINGS.

1. The Session of the Institution shall commence annually on the first Tuesday in November, and shall continue till the end of April, and it shall be in the power of the Council to protract the Session, if it appear advisable.

2. The Meetings of the Institution shall be as follows:—1st, the Annual General Meeting of Corporate Members only. 2nd, Ordinary Meetings. 3rd, Special General Meetings of Corporate Members only, for the purpose of making, altering, and establishing By-laws and Regulations, or for any other special business for which such Meetings may be convened.

3. The Annual General Meeting of the Institution shall be held on the last Tuesday of the Session, at eight o'clock in the evening, to receive and deliberate upon the Report of the Council on the state of the Institution, with the annual statement of the Accounts, and to elect the Council and Officers for the ensuing year.

4. The Ordinary Meetings shall be held on every Tuesday, during the Session, at eight o'clock in the evening, with the exception of the Tuesdays between the Tuesday previous to Christmas Eve and the second Tuesday in January, and also with the exception of Easter Tuesday; but it shall be in the power of any Ordinary Meeting, on the recommendation of the Council, to make such other exceptions as may appear advisable. No new question shall be introduced, or motion be made, after ten o'clock.

5. The business of the Ordinary Meetings of the Institution

shall be conducted as nearly as possible in the following order:—

1. The Minutes of the preceding meeting to be read, and after having been confirmed, to be signed by the Chairman.

2. Business arising out of the Minutes to be entered on.

3. Communications from the Council to be brought forward.

4. Candidates for election to be announced.

5. Any individual present for the first time since his election, having paid the usual contributions, and signed the Forms and the Register, to be introduced by the Chairman to the Meeting.

6. Original Communications to be read and discussed.

7. Candidates for election to be balloted for.

6. Every Corporate Member shall have the privilege of introducing one stranger, to be present at the Ordinary Meetings of the Institution, on writing his name in a book provided for that purpose, or sending with him a card signed with his name, according to a Form provided.

7. No question shall be discussed, or motion be made, at the Ordinary Meetings, relative to the direction and management of the concerns of the Institution; such direction and management being vested in the Council, under the control of the Charter and By-Laws, and of the Resolutions of Special General Meetings.

8. The Council may at any time call a Special General Meeting of Corporate Members for a specific purpose relative to the direction and management of the concerns of the Institution; and the Council are at all times bound to do so on a requisition in writing of twenty Corporate Members, specifying the nature of the business to be transacted.

9. A notice shall be sent to those Corporate Members who reside in the United Kingdom, at least seven days before the time appointed by the Council for such Special General Meeting; and the notice shall specify the nature of the business to be transacted, and no other than that business shall be transacted at that Meeting. All Corporate Members shall have a right, subject to the provision of Section V., Article 8, to attend and vote, and fifty shall constitute a quorum.

Section XIII.

OTHER SOCIETIES AND LECTURES.

1. The Council shall have power to grant, from time to time, as they may think fit, the use of the rooms of the Institution to any Society for purposes analogous to those of the Institution, and to any persons who may be desirous of having Lectures delivered on subjects connected with the objects of the Institution.

Section XIV.

ENACTMENT OF BY-LAWS AND REGULATIONS.

1. The Council, when they may consider it expedient to propose the enactment of any new By-Law or Regulation, or the alteration or repeal of any existing one, shall summon a Special General Meeting of Corporate Members to decide on the same. And the Council are at all times bound to do so on a requisition in writing of twenty Corporate Members, specifying the particular new By-Law or Regulation, or the alteration or repeal of any existing one, which they recommend.

2. A notice shall be sent to those Corporate Members who reside in the United Kingdom, at least seven days before the time appointed by the Council for such Special General Meeting. The notice shall state the general tenour and objects of any new By-Law or Regulation or the alteration or repeal of any existing one, which is to be proposed and discussed; and the business of the Meeting shall be limited thereto. All the Corporate Members of the Institution (but none other than Corporate Members) shall have a right, subject to the provision of Section V., Article 8, to attend and vote, and fifty shall constitute a quorum.

3. No new By-Law or Regulation, or alteration or repeal of any existing By-Law or Regulation, shall be proposed at any Meeting of the Institution, except in the manner above prescribed.

4. It shall be sufficient in all cases if the Forms in the Appendix are substantially followed, and no act or proceeding shall be invalid by reason of any formal defect.

Section XV.

THE PROPERTY OF THE INSTITUTION.

1. The property and effects of the Institution, of what kind soever, are vested in the Corporate Members for the time being, for the use of the body politic and corporate solely, in furtherance of the public and scientific objects contemplated in the Charter.

2. Under no pretence whatever shall such property and effects, or the income or revenue of the Institution, derived from voluntary contributions or otherwise howsoever, be applied in making any dividend, gift, division, or bonus, unto or between any of the Corporate Members, and the same is hereby expressly prohibited, in conformity with the fundamental law and invariable practice of the Institution, as acted upon from its first establishment; and therefore no proposition in contravention thereof shall be entertained by the Council, or by any Meeting, whether General or Special, of the Corporate Members of the Institution.

3. Every Paper, Map, Plan, Drawing, or Model, presented to the Institution, shall be considered the property thereof, unless there shall have been some previous arrangement to the contrary, and the Council may publish the same in any way and at any time they may think proper. But should the Council refuse or delay the publication of such Paper beyond a reasonable time, the Author thereof shall have a right to copy the same, and to publish it as he may think fit, having previously given notice, in writing, to the Secretary of his intention. Except as hereinbefore provided, no person shall publish, or give his consent for the publication of any communication presented and belonging to the Institution, without the previous consent of the Council.

4. The Library shall be open daily to all Members, Associate Members, Associates, Honorary Members, and Students, from 9.30 A.M. to 5.30 P.M., when they shall have the right to peruse and inspect all Books, Papers, Plans, Maps, &c., belonging to the Institution, and to make copies and extracts therefrom (doing no injury to the same), with the exception of such

documents as the Council shall order not to be inspected or copied; but none of the property of the Institution shall be taken away from the premises without the express permission of the Council.

Section XVI.

DONATIONS AND BEQUESTS.

1. The names of all persons who have presented any additions to the Library, or to the collections of Plans and Models, or who have made any voluntary contribution to the funds of the Institution, shall be recorded and published as benefactors to the Institution.

2. Every person desirous of bequeathing to the Institution any Manuscripts, Books, Maps, Plans, Drawings, Instruments, or other personal property, is requested to make use of the following form in his will:

> "I give and bequeath to The Institution of Civil
> " Engineers, incorporated by Royal Charter, dated June
> " the 3rd, 1828, [*here enumerate and particularize the*
> " *effects or property to be bequeathed:*] And I hereby
> " declare that the receipt of the Treasurer of the said
> " Institution for the time being shall be an effectual dis-
> " charge to my executors for the said legacy or bequest."

APPENDIX TO THE BY-LAWS.

APPENDIX,

CONTAINING FORMS REFERRED TO

IN

THE BY-LAWS.

Form A.

A _____ B _____ of ________________________________

___________________________ being upwards of twenty-five years of age, born on the __________ day of ___________ 18____, and being desirous of belonging to The Institution of Civil Engineers, I recommend him, from personal knowledge, as in every respect worthy of that distinction, because

[*Here specify distinctly the Qualifications of the Candidate according to the spirit of Articles* 2, 3, 5 *and* 6, *Sect. II., of the By-Laws.*]

On the above grounds, I beg leave to propose him to the Council as a proper person to belong to the Institution.

Signed, (A. B.) *Corporate Member.*

Dated this ______ day of ________ 18 _.

We, the undersigned, concur in the above recommendation from personal knowledge, and being fully convinced that A. B. is in every respect a proper person to belong to the Institution.

Signed, (X. Y.) *Corporate Members.*

[*Undertaking to be signed by the Candidate.*]

I, the undersigned, do hereby promise, that, in the event of my election, I will be governed by the Royal Charters of the Institution, and by the By-Laws and Regulations as they are now formed, or as they may hereafter be altered, amended, or enlarged, under the powers of the said Charters; and that I will promote the objects of the Institution as far as may be in my power, and will present to the Institution an Original

Communication, model, or scientific work for the library, within the space of twelve months from the date of my election.

Signed,________________________

The Council, having considered the above recommendation, present A. B. to be balloted for as a ________ of The Institution of Civil Engineers.

Signed,________________________

Chairman.

Dated this _______ day of ______________ 18___.

Form B.

(STUDENT.)

A ______ B_____ of____ born on the ___________ day of ____________ 18 ___, being desirous of admission as a Student of The Institution of Civil Engineers, I recommend him, from personal knowledge, as worthy of that privilege, and as coming within the Rules appertaining to that class, viz.: that he is upwards of eighteen years of age, and is under twenty-five years of age, and is, or has been, *bonâ fide*, in the course of preparation and training under me, with the object of becoming engaged in the design or in the construction of such works as are comprised within the profession of a Civil Engineer as defined by the Charter.

____________________ {Signature of the Proposer, who must be a Corporate Member of the Institution.

____________________ Signature of the Candidate.

Dated this _______ day of ______________ 18 __.

The Council, having considered the above recommendation, admit __________________________________ as a Student of The Institution of Civil Engineers.

Signed,________________________

Chairman.

Dated this _______ day of ____________ 18___.

FORM C.

WE, whose names are hereunto subscribed, submit to the Council of THE INSTITUTION OF CIVIL ENGINEERS the propriety of transferring A______B____________of____________born on the____ day of______18__, from the class of Associate Members, in which he was elected on the________day of_______18____, to the class of MEMBERS, because______.

[*Here specify distinctly the Qualifications of the Candidate according to the spirit of Article 2, Sect. II. of the By-Laws.*]

Witness our hands this________day of__________________18___

Signed,____________________

The Council of THE INSTITUTION OF CIVIL ENGINEERS, meeting on the______________day of_______________________18____ transfer A. B. from the class of Associate Members to the class of Members.

Signed,______________________

Chairman.

FORM D.

SIR, *The Institution of Civil Engineers.*

________________, 18 .

I have the honour to inform you that you were duly made a ________________ of THE INSTITUTION OF CIVIL ENGINEERS, on the _________day of_____________.

According to the Regulations of the Institution, you are required as __________to pay being your admission fee, and subscription for the current year, and to return the accompanying obligation with your signature, within two months of the date of your election [*or transfer*]; otherwise your election [*or transfer*] will be void. These conditions being complied with, you will be considered as a _____________of the Institution, when the diploma of your election [*or transfer*], and any publications or notices to which you are entitled, will be forwarded according to your directions.

I beg to direct your attention to Section V. of the By-Laws, and to point out that all annual subscriptions become due on the 1st of January in each year for the year then commencing.

I am, Sir, &c.

Form E.

I, the undersigned, having become_______________________of THE INSTITUTION OF CIVIL ENGINEERS, do hereby promise that I will be governed by the Royal Charter of the Institution, and by the By-Laws and Regulations of the said Institution as they are now formed, or as they may hereafter be altered, amended, or enlarged, under the powers of the said Charter; and I promise to promote the objects of the said Institution as far as shall be in my power, and to attend the meetings thereof as often as I conveniently can. Provided that, whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) be free from this obligation.

I also engage to present to the Institution an Original Communication, drawing, plan, or model of engineering interest, or some scientific work or the library, within the space of twelve months from the date of my election [*or transfer*].

Witness my hand, this________day of______________18___

Form F.

SIR, *The Institution of Civil Engineers.*

________________, 18___.

I have the honour to inform you, that the Council of THE INSTITUTION OF CIVIL ENGINEERS, meeting on the________________day of __________18______, admitted you as a Student of the Institution.

According to the Regulations of the Institution, you are required to pay the sum of________________, being the amount of your first subscription, within two months from the date of your admission, otherwise the admission will be void. When such payment has been made, you will become entitled to the privileges of your class.

I beg to direct your attention to Section V. of the By-Laws, and to point out that all annual subscriptions become due on the 1st of January in each year for the year then commencing.

I am, Sir, &c.

Form G.

The Institution of Civil Engineers.

______________, 18__.

Sir,

I am directed by the Council of The Institution of Civil Engineers to inform you that by a Resolution passed at a Special Meeting of the Council on the ________ of ____________ they have, acting under the powers conferred upon them by Article 11, Section III. of the By-laws and Regulations of the Institution, ordered your name to be erased from the Register, and have declared you to be no longer a ____________ of the Institution.

I am, Sir, etc.

Form H.

Sir,

The Institution of Civil Engineers.

______________, 18___.

I am directed by the Council of The Institution of Civil Engineers to draw your attention to Articles 8 and 10, Section V. of the By-Laws, and to remind you, that the sum of £________________ of your annual subscriptions to the funds of the Institution remains unpaid, and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion, as to using the power vested in them by Article 10, Section V., of the By-Laws and Regulations.

I am, Sir, &c.

Form I.

Sir,

The Institution of Civil Engineers.

______________, 18_____.

I am directed by the Council of The Institution of Civil Engineers to inform you, that in consequence of the non-payment of your arrears of subscription, and in pursuance of Article 10, Section V., of

the By-Laws and Regulations, the Council have declared by special vote, on the _ day of ________ 18____, that you have forfeited your claim in future to belong to the Institution, and your name will be in consequence expunged from the Register or lists, unless payment is made previous to________________

But notwithstanding such forfeiture as regards the future, I am directed to call upon you for payment of your arrears amounting to £_ : _:_ .

I am, Sir, &c.

LIST OF MEMBERS

1 JULY, 1904.

The Institution of Civil Engineers.

PAST-PRESIDENTS.

Mar. 1820. *Thomas Telford*, F.R.S.
Jan. 1835. *James Walker*, F.R.S.
Jan. 1845. *Sir John Rennie*, F.R.S.
Jan. 1848. *Joshua Field*, F.R.S.
Dec. 1849. *Sir William Cubitt*, F.R.S.
Dec. 1851. *James Meadows Rendel*, F.R.S.
Dec. 1853. *James Simpson*.
Dec. 1855. *Robert Stephenson*, F.R.S., M.P.
Dec. 1857. *Joseph Locke*, F.R.S., M.P.
Dec. 1859. *George Parker Bidder*.
Dec. 1861. *Sir John Hawkshaw*, F.R.S.
Dec. 1863. *John Robinson McClean*, M.P.
Dec. 1865. *Sir John Fowler*, Bart., K.C.M.G., LL.D.
Dec. 1867. *Sir Charles Hutton Gregory*, K.C.M.G.
Dec. 1869. *Charles Blacker Vignoles*, F.R.S.
Dec. 1871. *Thomas Hawksley*, F.R.S.
Dec. 1873. *Thomas Elliot Harrison*.
Dec. 1875. George Robert Stephenson.
Dec. 1877. *John Frederic La Trobe Bateman*, F.R.S.
Dec. 1879. *William Henry Barlow*, F.R.S.
Dec. 1880. *James Abernethy*.
Dec. 1881. *Lord Armstrong*, C.B., LL.D., D.C.L., M.A.I., F.R.S.
Dec. 1882. *Sir James Brunlees*.
Dec. 1883. *Sir Joseph William Bazalgette*, C.B.
Dec. 1884. *Sir Frederick Joseph Bramwell*, Bart., D.C.L., LL.D., F.R.S.
May 1886. *Edward Woods*.
June 1887. *Sir* George Barclay Bruce.
May 1889. *Sir John Coode*, K.C.M.G.
May 1891. *Sir George Berkley*, K.C.M.G.
May 1892. *Harrison Hayter*.
May 1893. *Alfred Giles*.
May 1894. *Sir Robert Rawlinson*, K.C.B.
May 1895. *Sir* Benjamin Baker, K.C.B., K.C.M.G., D.Sc., LL.D., M.A.I., F.R.S.
June 1896. *Sir* John Wolfe Barry, K.C.B., LL.D., F.R.S.
April 1898. *Sir* William Henry Preece, K.C.B., F.R.S.
Nov. 1899. *Sir* Douglas Fox.
Nov. 1900. James Mansergh, F.R.S.
Nov. 1901. Charles Hawksley.
Nov. 1902. John Clarke Hawkshaw, M.A.

(*The names of those deceased are printed in italics.*)

The Institution of Civil Engineers.

Council:

PRESIDENT.

Sir WILLIAM HENRY WHITE, K.C.B., D.Sc., LL.D., F.R.S.

VICE-PRESIDENTS.

FRANCIS WILLIAM WEBB.
Sir GUILFORD LINDSEY MOLESWORTH, K.C.I.E.
Sir ALEXANDER RICHARDSON BINNIE.
ALEXANDER BLACKIE WILLIAM KENNEDY, LL.D., F.R.S.

MEMBERS.

Sir BENJAMIN BAKER, K.C.B., K.C.M.G., D.Sc., LL.D., M.A.I., F.R.S., *Past-President.*
Sir JOHN WOLFE BARRY, K.C.B., LL.D., F.R.S., *Past-President.*
CUTHBERT ARTHUR BRERETON.
JOHN BROWN, C.M.G.
ROBERT ELLIOTT-COOPER.
ROOKES EVELYN BELL CROMPTON, C.B.
WILLIAM JOHN CUDWORTH.
CECIL WEST DARLEY, I.S.O.
GEORGE FREDERICK DEACON, LL.D.
FRANCIS ELGAR, LL.D., F.R.S.
WILLIAM ROBERT GALBRAITH.
JOHN CLARKE HAWKSHAW, M.A., *Past-President.*
GEORGE HENRY HILL.
JAMES CHARLES INGLIS.
GEORGE ROBERT JEBB.
THOMAS COLTRIN KEEFER, C.M.G.
JOHN ALLEN MCDONALD.
JAMES MANSERGH, F.R.S., *Past-President.*
WILLIAM MATTHEWS, C.M.G.
Hon. CHARLES ALGERNON PARSONS, F.R.S.
ALEXANDER ROSS.
Sir WILLIAM SHELFORD, K.C.M.G.
ALEXANDER SIEMENS.
HENRY CHARLES STANLEY.
JOHN STRAIN.
Sir JOHN ISAAC THORNYCROFT, LL.D., F.R.S.
WILLIAM CAWTHORNE UNWIN, B.Sc., F.R.S.
FREDERICK ROBERT UPCOTT, C.S.I.
Sir EDWARD LEADER WILLIAMS.
ALFRED FERNANDEZ YARROW.

*** *This Council will continue until November.* 1904.

Officers:

AUDITORS.
PERCIVAL DAVIS GRIFFITHS.
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TREASURER.
GEORGE JOHN MARJORIBANKS.

HONORARY SECRETARY.
JAMES FORREST.

SECRETARY.
J. H. T. TUDSBERY, D.Sc.

ENGINEERING CONFERENCE, 1897.

President—Sir JOHN WOLFE BARRY, K.C.B., LL.D., F.R.S.

OFFICERS OF THE SECTIONS.

Section I.—Railways.

Chairman — Sir Benjamin Baker, K.C.B., K.C.M.G., D.Sc., LL.D., M.A.I., F.R.S.

Vice-Chairmen: Sir Douglas Fox; Sir George Bruce; H. Copperthwaite; James Barton, B.A.

Hon. Secretaries: R. Elliott-Cooper; A. Ross

Section II.—Harbours, Docks and Canals.

Chairman—Harrison Hayter

Vice-Chairmen: Sir E. Leader Williams; A. G. Lyster; Vice-Admiral Sir George Nares, K.C.B.; Col. Sir Colin Scott-Moncrieff, K.C.M.G.

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Section III.—Machinery and Transmission of Power.

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Section IV.—Mining and Metallurgy.

Chairman—T. Forster Brown.

Vice-Chairmen: W. Shelford, C.M.G.; Sir Lowthian Bell, Bart., LL.D., F.R.S.; Sir W. T. Lewis, Bart.

Hon. Secretaries: R. J. Frecheville; R. A. Hadfield

Section V.—Shipbuilding.

Chairman—Sir William White, K.C.B., D.Sc., LL.D., F.R.S.

Vice-Chairmen: Francis Elgar, LL.D., F.R.S.; Rt. Hon. W. J. Pirrie, P.C., LL.D.; Sir Edward Reed, K.C.B., F.R.S., M.P.

Hon. Secretaries: Professor J. H. Biles; Sir J. I. Thornycroft, F.R.S.

Section VI.—Waterworks, Sewerage and Gasworks.

Chairman—James Mansergh, F.R.S.

Vice-Chairmen: G. H. Hill; H. P. Boulnois; George F. Deacon, LL.D.; Sir George Livesey

Hon. Secretaries: Walter Hunter; J. H. Lynde

Section VII.—Applications of Electricity.

Chairman—Sir William Preece, K.C.B., F.R.S.

Vice-Chairmen: J. A. Ewing, M.A., B.Sc., F.R.S.; E. Hopkinson, M.A., D.Sc.; Alexander Siemens

Hon. Secretaries: C. E. Spagnoletti; James Swinburne

(*The names of those deceased are printed in italics.*)

ENGINEERING CONFERENCE, 1899.

President—SIR WILLIAM HENRY PREECE, K.C.B., F.R.S.

OFFICERS OF THE SECTIONS.

SECTION I.—RAILWAYS.

Chairman—SIR DOUGLAS FOX.

Vice-Chairmen: James Barton, B.A.; Sir George Bruce; R. Elliott-Cooper; *C. de N. Forman.*

Hon. Secretaries: C. A. Brereton; A. Ross; W. B. Worthington, B.Sc.

SECTION II.—HARBOURS, DOCKS AND CANALS.

Chairman — SIR JOHN WOLFE BARRY, K.C.B., LL.D., F.R.S.

Vice-Chairmen: A. G. Lyster; William Matthews, C.M.G.; Sir E. Leader Williams.; B. H. Blyth, M.A.

Hon. Secretaries: J. Charles Coode; L. F. Vernon-Harcourt, M.A.; W. H. Wheeler

SECTION III.—MACHINERY.

Chairman—SIR JAMES KITSON, Bart., M.P.

Vice-Chairmen: Sir Andrew Noble, Bart., K.C.B., F.R.S.; F. W. Webb; W. Dean; A. Tannett-Walker

Hon. Secretaries: John A. F. Aspinall; E. B. Ellington; H. Graham Harris

SECTION IV.—MINING AND METALLURGY.

Chairman—E. WINDSOR RICHARDS.

Vice-Chairmen: T. Forster Brown; Sir Lowthian Bell, Bart., LL.D., F.R.S.; E. P. Martin; Sir *W. C. Roberts-Austen*, K.C.B., F.R.S.

Hon. Secretaries: Sidney H. Farrar; R. A. Hadfield

SECTION V.—SHIPBUILDING.

Chairman.

SIR EDWARD REED, K.C.B., F.R.S., M.P.

Vice-Chairmen: Sir William White, K.C.B., D.Sc., LL.D., F.R.S.; Francis Elgar, LL.D., F.R.S.; Rt. Hon. W. J. Pirrie, P.C., LL.D.; Sir J. I. Thornycroft, F.R.S.

Hon. Secretaries: S. W. Barnaby; Professor J. H. Biles; A. E. Seaton

SECTION VI.—WATERWORKS, SEWERAGE AND GASWORKS.

Chairman—GEORGE HENRY HILL.

Vice-Chairmen: James Mansergh, F.R.S.; Charles Hawksley; George F. Deacon, LL.D.; Harry E. Jones

Hon. Secretaries: George Chatterton, M.A.; Walter Hunter; J. H. Lynde

SECTION VII.—APPLICATIONS OF ELECTRICITY.

Chairman.

ALEXR. B. W. KENNEDY, LL.D., F.R.S.

Vice-Chairmen: Sir *Frederick Bramwell*, Bart., D.C.L., LL.D., F.R.S.; Alexander Siemens; J. A. Ewing, M.A., B.Sc., F.R.S.; E. Hopkinson, M.A., D.Sc.

Hon. Secretaries: *Lt.-Col.* R. E. B. Crompton, C.B; James Swinburne; J. C. Vaudrey

(*The names of those deceased are printed in italics.*)

ENGINEERING CONFERENCE, 1903.

President—JOHN CLARKE HAWKSHAW, M.A.

OFFICERS OF THE SECTIONS.

SECTION I.—RAILWAYS.

Chairman—Sir GUILFORD MOLESWORTH, K.C.I.E.

Vice-Chairmen
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- James C. Inglis
- J. Allen McDonald
- William Shelford, C.M.G.

Hon. Secretaries
- G. E. W. Cruttwell
- Basil Mott
- W. B. Worthington, B.Sc.

SECTION II.—HARBOURS, DOCKS AND CANALS.

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Vice-Chairmen
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- C. A. Brereton
- William Matthews, C.M.G.
- H. H. Wake

Hon. Secretaries
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- W. H. Wheeler

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Chairman—ALEXANDER B. W. KENNEDY, LL.D., F.R.S.

Vice-Chairmen
- John A. F. Aspinall
- W. H. Maw
- Hon. C. A. Parsons, F.R.S.
- A. T. Tannett-Walker

Hon. Secretaries
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- E. B. Ellington
- H. Graham Harris

SECTION IV.—MINING AND METALLURGY.

Chairman—E. P. MARTIN

Vice-Chairmen
- E. Windsor Richards
- R. A. Hadfield
- J. B. Simpson
- Arthur Sopwith
- John Strain

Hon. Secretaries
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- Sidney H. Farrar
- Archibald P. Head

SECTION V.—SHIPBUILDING.

Chairman—Sir JOHN I. THORNYCROFT, LL.D., F.R.S.

Vice-Chairmen
- Archibald Denny
- Philip Watts, LL.D., F.R.S.
- H. H. West
- A. F. Yarrow

Hon. Secretaries
- S. W. Barnaby
- John List, R.N.R.
- A. E. Seaton

SECTION VI.—WATERWORKS, SEWERAGE AND GASWORKS.

Chairman—Sir ALEXANDER BINNIE

Vice-Chairmen
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- George F. Deacon, LL.D.
- Walter Hunter
- Corbet Woodall

Hon. Secretaries
- E. P. Hill
- G. Maxwell Lawford
- E. H. Stevenson

SECTION VII.—APPLICATIONS OF ELECTRICITY.

Chairman—ALEXANDER SIEMENS

Vice-Chairmen
- *Lt.-Col.* R. E. B. Crompton, C.B.
- R. K. Gray
- Edward Hopkinson, M.A., D.Sc.
- James Swinburne

Hon. Secretaries
- H. R. J. Burstall
- A. H. Preece
- J. C. Vaudrey

ASSOCIATIONS OF STUDENTS.

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HON. SECRETARY.—JOHN M. HOGG, 12 India Street, Glasgow.

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PRESIDENT.—J. CARTWRIGHT, M.Inst.C.E.

VICE-PRESIDENTS.—H. CONGREVE, J. A. SANER, J. P. E. C. STROMEYER, S. S. PLATT, MM.Inst.C.E.

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PRESIDENT.—JOHN PRICE, M.Inst.C.E.

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HON. SECRETARIES.—A. DYSON, 51 High Street, Harborne, Birmingham; and F. G. HILL.

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YORKSHIRE (*Established* 1894–95).

PRESIDENT.—W. J. CUDWORTH, M.Inst.C.E.

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MEMBERS OF COUNCIL.—G. H. W. DAWSON, C. GRIBBLE, J. F. LISTER.

HON. SECRETARY.—C. T. FIRTH, Prospect House, Idle, Bradford.

*** The Members of Council and Honorary Secretaries are Students of the Institution.

ENUMERATION.

	1 July, 1903.	1 July, 1904
Honorary Members	19	19
Members	2,122	2,177
Associate Members	4,059	4,113
Associates	280	275
Students	979	1,075
Total	7,459	7,659

NOTICE.

It is particularly requested that every change of residence, as well as of Telegraphic Address and Telephone Number, or any inaccuracy or omission in prefixes and dates, may be communicated without delay to

The Secretary,
The Institution of Civil Engineers,
Great George Street, Westminster, S.W.

In the following List the *words* in brackets denote Telegraphic Addresses; the *figures*, Telephone Numbers, referring to the respective local Exchanges.

The prefix (✠) indicates the contributor of a Paper published in the Minutes of Proceedings, or of an Engineering Conference Note.
„ (T) indicates the recipient of a Telford Medal.
„ (t) „ „ Telford Premium.
„ (W) „ „ Watt Medal.
„ (S) „ „ George Stephenson Medal or Prize.
„ (M) „ „ Miller Scholarship.
„ (m) „ „ Miller Prize.
„ (*m*) „ „ Manby Premium.
„ (H) „ „ Howard Quinquennial Prize.
„ (C) „ „ Crampton Prize.
„ (*t*) „ „ Trevithick Premium.
„ (*f*) „ „ James Forrest Medal.
„ (J) „ „ Joule Medal.
„ (B) „ „ Bayliss Prize.
„ (L) „ deliverer of one of the Special Series of Lectures.
„ (F) „ deliverer of a James Forrest Lecture.
„ (*) „ a former Student.

PATRON.

HIS MAJESTY EDWARD VII., OF THE UNITED KINGDOM OF GREAT BRITAIN AND IRELAND AND OF THE BRITISH DOMINIONS BEYOND THE SEA, KING, EMPEROR OF INDIA.

Date of Election.	HONORARY MEMBERS.	
1895 Nov. 12.	HIS IMPERIAL MAJESTY WILHELM II., GERMAN EMPEROR AND KING OF PRUSSIA.	
1877 Mar. 13.	HIS MAJESTY LEOPOLD II., KING OF THE BELGIANS.	
1893 May 30.	H.R.H. GEORGE, PRINCE OF WALES, K.G., P.C.	
1872 May 7.	H.R.H. ARTHUR, DUKE OF CONNAUGHT, K.G., P.C.	
1903 Apr. 7.	H.H. PRINCE AUGUSTE D'ARENBERG	Compagnie Universelle du Canal Maritime de Suez, Rue Charras 9, Paris.
1883 Dec. 4. 1901 Mar 5.	*Lord* ALVERSTONE, G.C.M.G., P.C., LL.D. (*Cantab.*)	Hornton Lodge, Pitt Street, Kensington, W.
1903 Apr. 7.	*The Right Hon.* JOSEPH CHAMBERLAIN, P.C., F.R.S., M.P.	40 Prince's Gardens, S.W.
1895 May 21.	OCTAVE CHANUTE	413 East Huron Street, Chicago, U.S.
1903 Mar. 3.	The *Earl* of CROMER, G.C.B., G.C.M.G., K.C.S.I., C.I.E., P.C.	British Agency, Cairo.
1894 Jan. 9.	The *Duke* of DEVONSHIRE, K.G., P.C., LL.D. (*Cantab.*)	Devonshire House, Piccadilly, W.
1901 Apr. 23.	*Sir* JAMES DEWAR, M.A. (*Edin.*), LL.D. (*Edin., Glas. and St. Andrew's*)	Royal Institution, Albemarle Street, W.
1903 Apr. 7.	*Sir* ARCHIBALD GEIKIE, F.R.S.	10 Chester Terrace, Regent's Park, N.W.
1904 Jan. 12.	*Viscount* GOSCHEN, P.C., D.C.L. (*Oxon.*), LL.D. (*Cantab.*) ..	Seacox Heath, Hawkhurst, Sussex.
L ✠ 1874 May 12. 1889 May 21.	*Lord* KELVIN, G.C.V.O., O.M., P.C., D.C.L. (*Oxon.*), LL.D. (*Cantab.*), F.R.S.	Netherhall, Largs, Ayrshire.
.04 Feb. 2.	*Viscount* KITCHENER OF KHARTOUM, *General* R.E., G.C.B., G.C.M.G., O.M., D.C.L., (*Oxon.*), LL.D. (*Cantab.*) ..	Commander-in-Chief of H.M. Forces in India.
1898 Apr. 5.	*Lord* LISTER, O.M., D.C.L. (*Oxon.*)	12 Park Crescent, Portland Place, [W.
1899 Feb. 7.	ALFRED PICARD	97 Quai d'Orsay, Paris.
1891 Jan. 13.	*Lord* RAYLEIGH, O.M., M.A., D.C.L. (*Oxon.*), D.Sc. (*Cantab. and Dubl.*), F.R.S.	Terling Place, Witham, Essex.
1901 Mar. 5.	*Sir* FREDERICK WILLIAM RICHARDS, G.C.B., *Admiral of the Fleet*	34 Hurlingham Court, S.W.

Total number of Honorary Members .. 19.

MEMBERS.

[M. Inst. C.E.]

	Date of Election and of Transfer.	MEMBERS.	
	1889 Jan. 8.	ABBATT, RICHARD HENRY ..	33 Mattock Lane, Ealing, W.
	1885 Dec. 1. 1898 Nov. 29.	*ABBOTT, WILLIAM SUTHERLAND	Sutton, Surrey Road, Bournemo[uth]
✠	1894 Jan. 9. 1899 Nov. 28.	ABELL, WILLIAM PRICE	Castle Hill, Duffield, Derby.
	1881 Jan. 11. 1885 May 19.	*ABERNETHY, GEORGE NEILL ..	4 Delahay Street, Westminster, S.
	1883 May 29. 1898 Mar. 1.	ABURROW, CHARLES	Box 534, Johannesburg, Transv[aal]
	1897 Apr. 6.	ACLAND, FRANCIS EDWARD DYKE, *Captain* R.A. *ret.*	76 Cheapside, E.C. (Bank 5232
	1892 Mar. 1. 1903 Dec. 22.	*ADAMS, FREDERICK	c.o. S. Pearson & Son, 10 Victo[ria] Street, S.W.
	1871 Dec. 5. 1883 May 1.	*ADAMS, HENRY	60 Queen Victoria Street, E.C. (Vib[ur]num, London. Bank 6006.)
S t ✠	1869 Apr. 6.	ADAMS, WILLIAM	Hillrise, Amersham Road, Put[ney]
	1896 Dec. 1. 1902 Dec. 2.	ADIE, ALFRED EDMOND ..	Glencoe, Portland Road, Edgbast[on]
	1889 Dec. 3. 1898 Apr. 26.	AGNEW, SAMUEL HEWETT ..	c.o. Chas. Tighe & Sons, 42 Lomba[rd] Street, E.C.
	1904 Jan. 12.	AIRD, CONRAD KEITH	
t m ✠	1867 May 21. 1874 Apr. 21.	AIRY, WILFRID, B.A. (*Cantab.*)	6 Queen Anne's Gate, Westminst[er] S.W.
✠	1898 Dec. 5. 1904 Jan. 19.	AITKEN, THOMAS	County Buildings, Cupar, Fife. N.
	1887 May 24. 1903 Dec. 22.	*AKBAR, ALI	P.W.D., Ahmedabad, India.
✠	1875 Mar. 2. 1879 Dec. 16.	ALBRECHT, CHARLES JOHN ..	
	1901 Apr. 23.	ALBY, AMÉDÉE MARIE JOSEPH ..	22 Rue de Tocqueville, Paris.
	1890 Mar. 4.	ALEXANDER, ANDREW MILLER	Thames Ironworks, Canning Town.
	1888 May 15. 1889 Apr. 2.	ALEXANDER, ARTHUR LYON ..	Light Ry. Co., Barsi, Bombay.
	1880 Dec. 7.	ALEXANDER, STANLEY DE VERE HASTINGS	Railway Dept., Sydney, N.S.W.
✠	1879 Feb. 4. 1884 May 27.	ALFORD, ROBERT GERVAISE, F.R.S.E.	Prison Commission, Home Offi[ce] Whitehall, S.W.
	1901 Dec. 3.	ALLAN, CHARLES EDWARD ..	Stormont, Belfast.
	1870 Feb. 1.	ALLAN, GEORGE	13 Austin Friars, E.C. (Clemati[s] London. Avenue 5773.)
✠	1890 May 20. 1900 Dec. 19.	ALLAN, PERCY	Roads & Bridges Dept., Sydne[y] N.S.W.
	1893 Feb. 7. 1900 Jan. 30.	*ALLEN, HERBERT EDWARD ..	Lindenthorpe, Roath Lake (Eas[t]) Cardiff.
✠	1889 Dec. 3. 1901 Dec. 11.	ALLEN, PARKER ROSCOE	Arbuthnot & Co., Madras.
✠	1883 Mar. 6. 1891 Apr. 7.	ALLEN, WILLIAM HENRY ..	Queen's Engineering Works, Be[d]ford.
✠	1872 Apr. 9.	ALLEYNE, *Sir* JOHN GAY NEWTON, *Bart.*	Chevin, Belper.
	1890 May 20.	ALLIOTT, JAMES BINGHAM ..	Bloomsgrove Works, Nottingha[m] (Manloves, Nottingham.)

Date of Election and of Transfer.	MEMBERS.	
1894 Dec. 4.	ALLMAN, EDWARD MCCARTHY	Goulburn, New South Wales.
1876 Apr. 4. 1880 Dec. 21.	ALLOTT, CHARLES SNEATH	46 Brown Street, Manchester. (Allotted, Manchester. 1952.)
1872 Feb. 6.	ALLPORT, HOWARD ASTON ..	Dodworth Grove, Barnsley.
1903 Mar. 3.	ALLPRESS, VINCENT SYDNEY ..	25 Queen Anne's Gate, S.W.
1902 Jan. 14.	ALSTON, WILLIAM MURRAY ..	16 Robertson Street, Glasgow.
✠ 1892 May 24. 1899 Jan. 10.	ANDERSON, FRANCIS PHILIP ..	King, Hamilton & Co., Calcutta.
1880 Feb. 3.	ANDERSON, GEORGE..	75 Victoria Street, S.W.
1888 May 1. 1896 Mar. 24.	*ANDERSON, JAMES HENRY ..	Caledonian Ry., 3 Germiston Street, Glasgow.
1885 Mar. 3. 1891 Nov. 3.	ANDERSON, ROBERT, C.M.G...	Uganda Ry., Mombasa, E. Africa.
1878 Feb. 5.	ANDERSON, WILLIAM	Teesdale Ironworks, Stockton-on-Tees.
1904 Jan. 12.	ANDERSON, WILLIAM HENRY ..	Olive Bank, Portobello, N.B.
1904 Jan. 12.	ANDERSON, WILLIAM PATRICK *Lieut.-Col. Canadian Militia*	64 Cooper Street, Ottawa, Canada.
1858 Jan. 12.	ANDREWS, ARTHUR THOMAS ..	26 Fairlawn Park, Chiswick, W.
1875 May 11. 1881 May 31.	ANDREWS, EDMUND..	Warren Lodge, Hampton Wick.
t ✠ 1881 Dec. 6. 1888 Jan. 17.	ANDREWS, THOMAS, F.R.S. ..	Wortley Ironworks, near Sheffield.
1866 Dec. 4. 1878 Apr. 9.	ANDREWS, THORNTON	Cefn Eithen, Swansea.
1877 Mar. 6.	ANDREWS, WILLIAM	15 Ashburnham Road, Tonbridge.
1859 Apr. 5. 1866 May 15.	ANGELL, LEWIS	Calside, Carlisle Road, Eastbourne.
1882 Dec. 5. 1893 Dec. 19.	ANGUS, DAVID	Arauco Co., Coronel, Chile.
1887 Feb. 1. 1894 Mar. 6.	ANGUS, JONATHAN	17 Victoria Street, S.W. (Fuimus, London. Westminster 344.)
1892 Dec. 6. 1901 Feb. 19.	ANSON, ERNEST, M.A. (*Oxon.*)	119 Victoria Street, S.W. (Bandobast, London. Victoria 666.)
1891 Dec. 1. 1900 Jan. 30.	*ANTHONY, CHARLES, JUN. ..	Municipality, East London, Cape Colony.
t ✠ 1879 Apr. 1.	APJOHN, JAMES HENRY, M.A. (*Dubl.*)	17 Victoria Street, S.W. (Upingo, London. Westminster 344.)
1864 Feb. 2. 1877 May 29.	APPLEBY, CHARLES JAMES ..	22 Walbrook, E.C.
1863 May 5. 1888 Oct. 30.	APPLETON, EDWARD	
1897 Dec. 7.	ARGOLLO, MIGUEL DE TEIVE E	São Francisco Ry., Alagoinhas, Bahia, Brazil.
1885 May 5.	ARGYLE, JOHN	Midland Ry., Derby.
1902 Mar. 4.	ARKWRIGHT, BERNARD GEORGE	Elswick Works, Newcastle-on-Tyne.
m 1877 May 29. 1890 Feb. 4.	*ARMSTRONG, WALTER YOUNG..	G. W. Ry., Paddington, W.
1900 Dec. 4.	ARMSTRONG, WILLIAM	Wingate, co. Durham.
1891 Jan. 13. 1896 Dec. 22.	ARNOT, WILLIAM	163 Hope Street, Glasgow. (Induction, Glasgow. Argyle 638.)
1901 Feb. 5.	ARNOTT, MARMADUKE HENRY	King, Hamilton & Co., Calcutta.
✠ 1892 Dec. 6. 1902 Feb. 18.	*ASHTON, HAROLD THOMAS, D.Sc. (*Victoria*)	Royal Arsenal, Woolwich.
1882 May 2.	ASKWITH, ROBERT	The Hall, Witton-le-Wear, co. Durham.
t ✠ 1881 Feb. 1. 1887 Nov. 22.	ASPINALL, JOHN AUDLEY FREDERICK	Gledhill, Mossley Hill Drive, Liverpool.
1871 Feb. 7. 1884 Oct. 14.	ATHERSTONE, GUYBON DAMANT	Box 92, Grahamstown, Cape Colony.
1896 Apr. 14. 1902 Feb. 11.	ATKINSON, HERBERT JEFCOATE, B.A.I. (*Dubl.*)	Tyrmynydd, Rhayader, Rads.

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	Date of Election and of Transfer.	MEMBERS.	
	1859 Apr. 5.	ATKINSON, WILLIAM	Erwood, Beckenham, S.E.
	1865 Feb. 7. 1879 Jan. 14.	AYLMER, RICHARD	71 Primrose Mansions, Prince Wales Road, Battersea Park, S.
✠	1878 Feb. 5.	AYRES, ARTHUR	Ashleigh, Truro Rd., Wood Green,
	1874 Dec. 1. 1889 Mar. 26.	*BAGGALLAY, HENRY CHARLES	13 Stanhope Place, Hyde Park,
	1890 Dec. 2.	BAGLEY, FREDERICK ROBERT ..	c.o. E.I.U.S. Club, 16 St. Ja Square, S.W.
	1886 Jan. 12. 1888 Oct. 30.	BAGNALL, HARVEY, M.A., B.A.I. (*Dubl.*)	Gwelo, Rhodesia.
	1889 Dec. 3. 1899 Jan. 10.	BAILEY, FRANK	64 Bankside, S.E.
	1896 Feb. 4.	BAILEY, THOMAS HENRY ..	55 Temple Row, Birmingham.
	1888 Feb. 7.	BAILLIE, JONATHAN ROBERT ..	c.o. R. A. Baillie, 9 Lordship Pa Stoke Newington, N.
	1891 Mar. 3.	BAINBRIDGE, CHARLES EDWARD	Shapwick Cottage, Bushey Hea Herts.
	1876 May 30.	BAIRD, GEORGE	Royal Thames Yacht Club, 7 Al marle Street, W.
T S t ✠	1867 Dec. 3. 1877 May 29.	BAKER, *Sir* BENJAMIN, K.C.B., K.C.M.G., D.Sc. (*Cantab.*), LL.D. (*Edin.*), M.A.I. (*Dubl.*), F.R.S. (*Past-President. Member of Council.*)	2 Queen Square Place, S.W. (Olig London. Westminster 33.)
	1895 May 21.	BAKER, HARRY VICTOR SAMPSON	P.W.D., Derajat Circle, Mult India.
	1881 Dec. 6. 1897 Mar. 29.	BAKER, JOHN BECKETT	598 Calle Dean Funes, Cordob Argentina.
	1888 May 15.	BAKEWELL, WILLIAM NEWTON	31 Herbert Road, Stockwell, S.W.
	1877 Feb. 6. 1886 Feb. 9.	*BALDRY, HENRY OSBORNE ..	21 Queen Anne's Gate, S.W.
	1884 Jan. 8. 1904 Feb. 23.	BALE, MANFRED POWIS ..	7 Walpole Gardens, Chiswick, W.
	1875 May 4. 1889 Apr. 9.	BALFOUR, DAVID	3 St. Nicholas Buildings, Newcast on-Tyne. (Balfour, Myre Ha Houghton-le-Spring. Newcast 2189. Houghton-le-Spring 6.)
	1892 Mar. 1. 1901 Feb. 19.	*BALFOUR, DAVID, Jun.	3 St. Nicholas Buildings, Newcast on-Tyne. (2189.)
m ✠	1892 May 24. 1902 Feb. 11.	*BALL, JAMES BENJAMIN	L.D. & E.C. Ry., Chesterfield.
	1874 Mar. 3. 1877 Nov. 27.	BALLARD, ROBERT	35 Wood Lane, Shepherd's Bush, W
	1898 Dec. 6.	BANISTER, GEORGE HENRY ..	Vickers, Sons, and Maxim, Barro in-Furness.
	1893 May 2. 1894 Oct. 16.	BARBER, JAMES PATTEN ..	Vestry Hall, Islington, N.
t ✠	1899 Jan. 10.	BARBER, THOMAS WALTER ..	17 Tothill St., Westminster, S.W.
	1895 Dec. 3.	BARDSLEY, GEORGE ROBERT ..	64 Bridge Street, Manchester.
	1885 Dec. 1. 1894 Nov. 6.	BARFIELD, SAMUEL GEORGE HERBERT, D.Sc. (*Lond.*) ..	Aidin Railway, Smyrna.
	1873 Mar. 4. 1877 Nov. 27.	BARKER, JOHN	20 Oppidans Rd., Primrose Hill, N.W
	1881 Feb. 1. 1889 Mar. 19.	BARKER, JOHN	Ellenbank, Leigham Court Roa Streatham Hill, S.W.
m ✠	1892 Dec. 6. 1902 Mar. 11.	*BARKER, JOHN HENRY	22 Cardington Road, Bedford.
	1891 Dec. 1. 1903 Dec. 22.	*BARKER, LÉON HARRY	Bengal-Nagpur Ry., Seesee Cha para, India.
	1889 May 7.	BARKER, ROBERT	S. E. & L. C. & D. Rys., Lond Bridge Station, S.E.

Date of Election and of Transfer.	MEMBERS.	
✠ 1892 Dec. 6. / 1901 Feb. 12.	BARLING, IVAN COLLINGWOOD ..	North Pier Works, Tynemouth.
✠ 1872 Dec. 3. / 1879 Dec. 23.	*BARLOW, CRAWFORD, B.A. (*Cantab.*)	Fordwich House, Sturry, Kent.
1880 May 4. / 1893 Dec. 12.	BARLOW, EDWIN SYDNEY ..	Grassfield Cottage, Pateley Bridge, Yorks.
1903 Mar. 3.	BARLOW, HAROLD	c/o H. S. King & Co., Pall Mall, S.W.
✠ 1881 May 3. / 1888 Mar. 6.	*BARNABY, SYDNEY WALKER ..	The Hollies, Chiswick Mall, W.
1886 Apr. 6. / 1889 Nov. 5.	BARNES, JOHN FREDERICK EVELYN, C.M.G...	Engineer, P.W.D., Natal.
1897 Jan. 12.	BARNETT, MICHAEL RATCLIFFE	Laurel Bank, Lancaster.
1879 Dec. 2.	BARNETT, PATRICK MOIR ..	Ivy Lodge, Westfield Terrace, Aberdeen.
1890 Apr. 1.	BARR, *Professor* ARCHIBALD, D.Sc. (*Glas.*)	University, Glasgow.
✠ 1882 Feb. 7.	BARR, GEORGE MORRISON ..	Dunedin, Otago, N.Z.
1874 Apr. 14. / 1881 May 3.	BARR, JAMES	221 West George Street, Glasgow.
1877 Apr. 10.	BARRASS, SAMUEL	10 Bevington Road, Beckenham.
1879 Dec. 2.	BARRETO, ANTONIO PAULO DE MELLO	Donna Luiza 17, Rio de Janeiro.
1883 Jan. 9. / 1891 Feb. 3.	*BARRINGTON, WILLIAM	10 George Street, Limerick.
✠ 1868 Apr. 7. / 1878 Feb. 19.	BARRON, FREDERICK CADOGAN	Nervion, Beckenham Grove, Shortlands, Kent.
✠ 1878 Feb. 5. / 1883 May 29.	BARRON, JAMES	216 Union Street, Aberdeen.
1887 Apr. 5. / 1897 Nov. 30.	*BARROW, WALTER DUNCAN ..	Burma Rys. Co., Rangoon, Burma.
1887 May 24. / 1893 May 16.	BARRY, ARTHUR JOHN	7 The Sanctuary, Westminster, S.W.
✠ 1868 Feb. 4.	BARRY, *Sir* JOHN WOLFE, K.C.B., LL.D. (*Glas.*), F.R.S. (*Past-President. Member of Council.*)	21 Delahay Street, Westminster, S.W. (Consilium, London. Westminster 24.)
1858 Feb. 2.	BARTHOLOMEW, WILLIAM HAMOND	Aire and Calder Office, Leeds.
1882 May 23. / 1893 Nov. 14.	BARTLETT, JAMES HERBERT ..	Middlesborough, Kentucky, U.S.
1884 Jan. 8. / 1894 Apr. 3.	BARTLETT, THOMAS WALTER	c.o. H. S. King & Co., Pall Mall, S.W.
1881 Feb. 1. / 1884 Mar. 4.	BARTON, EDWARD GOLDING ..	P.W.D., Darbhanga, Bengal.
✠ 1853 Mar. 1.	BARTON, JAMES, B.A. (*Dubl.*)	Exchange Buildings, Dundalk. (Barton, Exchange, Dunkalk.)
1881 Feb. 1.	*BARTON, *Sir* JOHN GEORGE, C.B.	Valuation Office, Dublin.
1896 Feb. 4. / 1904 Feb. 2.	BASSET, WALTER BASSETT ..	Watermouth Castle, Ilfracombe.
1883 Feb. 6. / 1895 Apr. 2.	BASSETT, ALEXANDER BARKER	Cheverell, Llandaff.
1892 Mar. 1. / 1902 Dec. 16.	*BATCHEN, THOMAS MACKENZIE	Board of Public Works, Custom House, Dublin.
1888 Dec. 4. / 1895 Oct. 22.	BATES, ONWARD	Bates & Rogers Construction Co., 1203 Manhattan Bldg., Chicago, U.S.
1878 Dec. 3.	BAXTER, WILLIAM	Ashburton, Canterbury, N.Z.
1885 Mar. 3. / 1894 May 8.	*BAYER, CHARLES ALBERT ..	Hydraulic Engineer's Office, Adelaide, South Australia.
1875 Feb. 2.	BAYLEY, KENNETT	Milford House, co. Carlow.
1883 May 29. / 1900 Mar. 27.	BAYLISS, GEORGE REGINALD ..	
1895 May 21.	BAYLISS, RAWLINSON TENNANT	11 Cornhill, E.C. (Sorrowful, London.)
✠ 1874 Jan. 13. / 1879 Apr. 8.	*BAZALGETTE, EDWARD	Cherney, Arthur Road, Wimbledon Park, S.W.

	Date of Election and of Transfer.	MEMBERS.	
t ✠	1885 May 19. 1893 Feb. 7.	*BEARE, *Professor* THOMAS HUDSON, B.A. (*Adelaide*), B.Sc. (*Lond.*), F.R.S.E.	Engineering Laboratory, Universit[y], Edinburgh.
W t ✠	1875 Mar. 2. 1886 Feb. 16.	BEAUMONT, WILLIAM WORBY	22 Outer Temple, 222 Strand, W.[C.] (Vibromotor, Lond. Gerrard 416[0].)
T t ✠	1860 Dec. 4.	BEAZELEY, ALEXANDER	4 Park Villas, Hanover Road, We[y]mouth.
S t ✠	1889 May 21. 1895 Nov. 26.	BECKETT, WILLIAM THOMAS CLIFFORD	W. Watson & Co., Calcutta.
	1884 May 27. 1897 Mar. 15.	BEDSON, JOSEPH PHILLIPS ..	8 Clifton Avenue, Fallowfield, Ma[n]chester.
	1894 Jan. 9. 1902 Dec. 16.	BEESLEY, WALTER	11 Victoria Street, S.W.
	1904 Jan. 12.	BEHR, HANS CHARLES	Johannesburg, Transvaal.
	1893 Dec. 5. 1901 Feb. 5.	BELL, ARCHIBALD GRAEME ..	P.W.D., Georgetown, Demerara.
	1881 Dec. 6. 1890 May 20.	*BELL, ARTHUR WILBRAHAM DILLON	P.W.D., Perth, Western Australia.
	1867 Apr. 2.	BELL, CHARLES NAPIER	G.P.O., Wellington, N.Z.
	1897 Dec. 7. 1902 Mar. 11.	BELL, GEORGE JOSEPH	County Surveyor, Carlisle.
✠	1866 Feb. 6. 1878 Dec. 3.	BELL, HENRY PURDON	Victoria, British Columbia.
t ✠	1867 May 21. 1868 Apr. 21.	BELL, IMRIE	49 Dingwall Road, Croydon.
S H t ✠	1867 May 21. 1873 Apr. 8.	BELL, *Sir* ISAAC LOWTHIAN, *Bart.*, LL.D. (*Edin.*), F.R.S.	Rounton Grange, Northallerton.
	1896 Dec. 1.	BELL, JAMES	22 Wilton Road, Craigmillar Par[k], Edinburgh.
t ✠	1879 Dec. 2.	BELL, JAMES RICHARD	Hazeldene, Ightham, Kent.
	1895 Dec. 3. 1902 Feb. 11.	BELL, LEONARD MOORE	Municipal Offices, Singapore, S.S.
	1896 Apr. 14. 1903 Mar. 31.	*BELL, NORRIS GARRETT	Railway Dept., Brisbane, Queens[-]land.
	1869 May 4.	BELL, VALENTINE GRAEME, C.M.G.	Director of Public Works, Jamaic[a].
	1882 Dec. 5. 1894 Jan. 30.	BELL, WILLIAM REID	Box 78, Potchefstroom, Transvaal.
✠	1892 Dec. 6. 1901 Feb. 19.	*BELLAMY, CHARLES VINCENT	Director of Public Works, Lago[s], West Africa.
	1885 May 5.	BELLAMY, GEORGE DAVID ..	6A Courtenay Street, Plymouth.
	1880 Dec. 7. 1897 Nov. 30.	*BELLASIS, EDWARD SKELTON	Mooltan, Punjab.
	1880 Feb. 3. 1902 Dec. 16.	*BELLINGHAM, AUGUSTUS WILLIAM HARVEY	Queen Anne's Mansions, Wes[t]minster, S.W.
	1871 Dec. 5.	BENEDICT, ERNEST	Clun House, Surrey Street, W.C. (Central 6635.)
	1893 Jan. 10. 1904 Feb. 16.	*BENGOUGH, CYRIL FRANCIS ..	Old Station House, Witton-le-We[ar].
	1889 Dec. 3. 1899 Jan. 17.	*BENT, BALDWIN HARRY, M.A. (*Cantab.*)	Heysham Harbour, Lancashire.
	1893 Jan. 10.	BENTON, JOHN, C.I.E., F.C.H.	c.o. H. S. King & Co., Pall Mall, S.W.
	1884 Dec. 2.	BERESFORD, JOHN STUART, C.I.E., M.E. (*Queen's*)	2 Carlton Gardens, Ealing, W.
	1877 Apr. 10. 1884 Apr. 1.	BERNAYS, JOSEPH	96 Newgate Street, E.C. (Anyber, London.)
	1895 Feb. 5. 1899 Nov. 28.	BERNAYS, LEWIS ADOLPHUS, Jun.	Railway Department, Brisban[e], Queensland.
	1873 Feb. 4. 1887 Feb. 22.	*BERRELL, WILLIAM	Thames Conservancy, Victoria Em[-]bankment, E.C.
	1885 May 19.	BERRIER-FONTAINE, JEAN-BAPTISTE LOUIS FÉLIX MARC ..	Boulevard de Strasburg 16, Toulo[n]-sur-mer (Var), France.
✠	1885 Dec. 1. 1902 Dec. 16.	BERRINGTON, RICHARD EVANS WILLOUGHBY	Graiseley, Wolverhampton.

	Date of Election and of Transfer.	MEMBERS.	
	1879 Feb. 4. / 1892 Nov. 22.	BERTODANO, CHARLES EDMUND DE	47 Victoria Street, S.W. (Euripides, London.)
	1890 Feb. 4. / 1903 Feb. 10.	BESANT, FREDERICK WILLIAM	Chilbridge, Wimborne, Dorset.
	1882 May 2. / 1894 May 22.	*BEST, CHARLES WILLIAM ..	County Surveyor, Brecon.
	1899 Dec. 5.	BEVIS, R. RATSEY	Ironworks, Birkenhead.
	1882 Feb. 7. / 1896 Dec. 22.	*BEWICK, THOMAS BURRELL ..	20 Copthall Avenue, E.C. (Bewick, London. London Wall 758.)
	1882 Mar. 7. / 1901 Feb. 19.	BEWLAY, HUBERT	Thomas Piggott & Co., Birmingham
	1882 Feb. 7.	BEZZI, *Chev.* TOMASO GAUDENZIO	Ypiranga Works, São Paulo, Brazil.
	1894 May 1. / 1898 Dec. 20.	BICKNELL, ROBERT HENRY ..	Local Government Board, Whitehall, S.W.
	1878 Mar. 5.	BIDDER, BARTHOLOMEW PARKER	c.o. Everett & Co., 51 Fetter Lane, E.C.
t ✠	1900 Jan. 9.	BIDDER, FREDERICK WILLIAM	13 Victoria Street, S.W.
	1903 Apr. 7.	BIDWELL, HARRY SHELFORD ..	Outer Barrier Works, Hodbarrow, Millom, Cumberland.
✠	1897 Apr. 6.	BILES, *Professor* JOHN HARVARD	10 University Gardens, Glasgow.
	1899 Jan. 10.	BILLINTON, ROBERT JOHN ..	Lea Hurst, Preston Park, Brighton.
3 t ✠	1865 Feb. 7. / 1873 May 20.	BINNIE, *Sir* ALEXANDER RICHARDSON (*Vice-President.*)	9 Great George Street, S.W. (Arbintro, London. Westminster 5070.)
	1892 Dec. 6. / 1900 Dec. 19.	*BINNIE, WILLIAM JAMES EAMES, B.A. (*Cantab.*)	9 Great George Street, S.W. (Arbintro, London. Westminster 5070.)
	1885 May 19.	BIRKBECK, MORRIS	Dippenhall Cottage, Farnham, Surrey.
	1882 Apr. 4. / 1893 Nov. 7.	BIRKINSHAW, ARTHUR HENRY	c.o. H. S. King & Co., Pall Mall, S.W.
	1900 Dec. 4.	BISHOP, ALEXANDER	Caledonian Railway, Glasgow.
	1870 Dec. 6. / 1877 Oct. 30.	BISSET, JAMES	Claremont, Cape Town, C.C.
	1875 May 4. / 1898 Apr. 5.	BLABER, CHARLES OLIVER ..	
	1897 Apr. 6. / 1903 Dec. 22.	BLACK, ROBERT SMITH	Algeciras Railway, Gibraltar.
	1888 Jan. 10. / 1892 Mar. 8.	BLACKBURN, ALEXANDER BEWICKE	Brush Electrical Engineering Co., Loughborough.
	1904 Mar. 1.	BLACKWELL, KENNET WILLIAM	Montreal Steel Works, Montreal, Canada.
	1884 Feb. 5. / 1897 Feb. 23.	*BLAIR, WILLIAM NISBET	Vestry Hall, St. Pancras Road, N.W.
	1873 Mar. 4. / 1885 Jan. 27.	BLAKESLEY, THOMAS HOLMES, M.A. (*Cantab.*)	The Elms, Eliot Park, Blackheath, S.E.
	1856 Mar. 4.	BLAKISTON, MATTHEW	Free Hills, Bursledon, Southampton.
	1895 Dec. 3.	BLIGH, WILLIAM GEORGE ..	Fotheringhay, Bexhill-on-Sea.
✠	1887 Apr. 5. / 1894 Feb. 27.	*BLOMFIELD, HAROLD ARTHUR	Department of Public Works, Wollongong, New South Wales.
✠	1878 Mar. 5.	BLOOD, BAGOT WILLIAM	Albert House, Dalkey, co. Dublin.
	1863 May 5.	BLOUNT, JOHN DARELL	Mapledurham, Reading.
	1877 Dec. 4. / 1901 Feb. 19.	BLOXSOM, MARTIN, B.A. (*Lond.*)	Hazlewood, Crumpsall Green, Manchester.
	1887 Feb. 1. / 1903 Dec. 22.	*BLUETT, FREDERICK	19 Bedford Circus, Exeter.
	1886 Jan. 12. / 1899 Nov. 28.	BLUNDELL, HARRY	Cheshire Lines, Central Station, Liverpool.
✠	1877 Feb. 6.	*BLYTH, BENJAMIN HALL, M.A. (*Edin.*), F.R.S.E. ..	17 Palmerston Place, Edinburgh.
✠	1892 May 24. / 1901 Dec. 17.	*BODY, JOHN BENJAMIN	Puente de Alvarado 15, Mexico City
	1900 Feb. 6.	BOGART, JOHN	16 Exchange Place, New York, U.S
	1866 Apr. 10. / 1877 Nov. 13.	BOHN, GEORGE	Imperial Chambers, Hull.

	Date of Election and of Transfer.	MEMBERS.	
	1891 Feb 3.	BOLLER, ALFRED PANCOAST, M.A. (*Penn.*)	1 Nassau Street, New York, U.S.
✠	1887 Feb. 1.	BOLTON, ALEXANDER JOSEPH	Calcutta.
	1884 Dec. 2.	BOND, CHARLES JOHN	South Indian Ry., Trichinopoly.
	1884 Feb. 5. 1896 Nov. 16.	BONN, CARL RODERIQUE LOUIS MENNI	180 Hope Street, Glasgow.
✠	1876 May 2. 1878 Dec. 31.	BOOTH, ROBERT BELL	Lalpuri, Silchester Road, Glengeary, co. Dublin.
	1891 Feb. 3. 1901 Dec. 17.	*BORROWMAN, WILLIAM CAMERON	Strathmore, West Hartlepool.
	1878 May 7.	BOSTOCK, JOHN HENRY	Harbour Works, Colombo, Ceylon.
	1879 Feb. 4. 1892 Nov. 1.	BOSWELL, ST. GEORGE JAMES, B.Sc. (*McGill*)	Harbour Works, Quebec, Canada.
	1877 Feb. 6. 1897 Mar. 2.	BOTLEY, CHARLES EDWARD ..	Gasworks, Hastings.
	1890 Dec. 2. 1895 Oct. 22.	BOUCHER, ARTHUR SACKVILLE	Sharpcliffe Hall, Ipstones, Stoke-on-Trent.
✠	1874 Feb. 3. 1878 Apr. 16.	*BOULNOIS, HENRY PERCY ..	Local Government Board, Whitehall, S.W.
	1886 Jan. 12. 1896 May 19.	*BOURKE, WALTER LONGLEY ..	Manor House, Elstree, Herts.
	1880 Dec. 7.	BOUSCAREN, LOUIS FREDERICK GUSTAVE	City Hall, Cincinnati, U.S.
✠	1876 Dec. 5. 1886 May 18.	*BOVEY, HENRY TAYLOR, M.A., LL.D. (*Cantab.*), F.R.S.	McGill University, Montreal, Canada
	1889 Dec. 3. 1900 Dec. 19.	BOWER, THOMAS	Ribble House, West Hartlepool.
	1876 Apr. 4. 1881 Feb. 22.	BOWSTEAD, CHARLES JAMES ..	Hyde Grange, Chalford, Glos.
	1882 Apr. 4. 1894 Oct. 30.	*BOYCE, HENRY GEORGE, F.C.H.	Allahabad, India.
✠	1854 Jan. 10. 1860 Feb. 14.	BOYLE, RICHARD VICARS, C.S.I.	3 Stanhope Terrace, Hyde Park, W.
	1884 Dec. 2. 1893 May 16.	*BOYNTON, FRANCIS, *Major R.E.*	R. E. Office, Warwick.
	1893 Dec. 5. 1903 Dec. 22.	*BRADLEY, JAMES WILLIAM ..	City Hall, Charing Cross Road, W.C.
C t ✠	1883 May 29. 1895 Jan. 29.	BRADY, ALFRED BARTON ..	Under Secretary, D.P.W., Brisbane, Queensland.
	1868 May 5.	BRADY, FRANCIS	12 St. Edmund's Terrace, N.W.
✠	1875 Dec. 7. 1878 Dec. 3.	BRADY, JOSEPH	367 Collins St., Melbourne, Victoria.
	1877 May 1.	BRAMALL, HENRY	Pendlebury Collieries, near Manchester.
	1897 Apr. 6.	*BRAND, ALLEN MASON	G. I. P. Ry., Engineer's Office, Bombay.
Tt Mm ✠	1883 May 28. 1899 Nov. 28.	*BREBNER, ALAN, B.Sc. (*Edin.*)	Croxton Villa, Eccleshall, Staffs.
	1874 May 5. 1899 Jan. 10.	BRENAN, GEORGE WOULFE ..	Albany Street Chambers, Oban, N.B.
	1891 Dec. 1.	BRERETON, ALFRED, C.S.I. ..	c.o. Grindlay & Co., Parliament Street, S.W.
	1880 Feb. 3.	BRERETON, CUTHBERT ARTHUR (*Member of Council.*)	21 Delahay St., Westminster, S.W. (Consilium, London. Westminster 24.)
	1865 Jan. 10.	BRERETON, ROBERT MAITLAND	Woodstock, near Portland, Oregon, U.S.
	1878 Mar. 5. 1885 Feb. 3.	BRETLAND, JOSIAH CORBETT ..	Bramcote, Craigavad, co. Down.
	1 Feb. 5.	BRIAN, SANTIAGO	31 Avenida Republica, Buenos Aires.
	Mar. 1. pr. 21.	*BRIGGS, JAMES	Midland Railway, Derby.
	ec. 6. ov. 7.	BRIGGS, JOHN HENRY	Howden, East Yorks.

	Date of Election and of Transfer.	MEMBERS.	
	1896 May 5.	Briggs, Roswell Emmons ..	Apartado 561, Mexico.
s ✠	1889 Dec. 3. 1896 Nov. 24.	*Brightmore, Arthur William, D.Sc. (*Victoria*)	Egham Hill, Egham, Surrey.
	1874 Mar. 3.	Brind, Alfred Walter ..	19 Madeley Road, Ealing, W.
t ✠	1874 May 5. 1886 Mar. 1.	Brittle, John Richard, F.R.S.E.	Farad Villa, Vanbrugh Hill, Blackheath, S.E.
	1868 Dec. 1.	Broadrick, George, F.R.S.E.	Broughton House, Broughton Road, Ipswich.
	1865 Feb. 7. 1877 Mar. 13.	Brock, Walter	Denny Brothers, Dumbarton.
	1904 Apr. 19.	Brock, Henry William ..	Denny Brothers, Dumbarton, N.B.
	1890 Jan. 14. 1897 Dec. 7.	Brodie, John Alexander ..	City Engineer, Liverpool.
	1886 Dec. 7. 1902 Mar. 4.	*Brodie, Robert	17 Priory Street, Birkenhead.
	1893 Dec. 5. 1896 Nov. 24.	Brot, Victor Edgar de Birchin de	North Western Railway, Lahore, India.
	1871 May 23. 1889 Nov. 26.	Bromley, Walter Brandreth	Chakrata, Brittany Road, St. Leonards.
	1883 Jan. 9. 1889 Nov. 15.	*Brookhouse, Robert Harold	Calle 25 de Mayo 81, Buenos Aires.
	1877 Dec. 4. 1892 Nov. 15.	Broom, George James Cottom	Boro' Engineer, St. Helens, Lancs.
	1876 Jan. 11. 1885 May 12.	*Brounger, Richard Ernest ..	Ferrocarril, San José, Costa Rica.
	1885 Dec. 1. 1904 Jan. 19.	*Brounger, Sydney George ..	36 Priory Road, Bedford Park, W.
✠	1890 Feb. 4.	Brown, Andrew	Wm. Simons & Co., Renfrew.
	1881 May 31. 1885 Nov. 10.	Brown, Arthur	Guildhall, Nottingham.
	1883 Dec. 4. 1894 Jan. 23.	Brown, Arthur Cardwell ..	Reconquista 144, Buenos Aires.
	1886 Feb. 2. 1893 Dec. 5.	Brown, Arthur Edward ..	Tower House, East Cowes, I.W.
	1894 Feb. 6. 1902 Jan. 28.	*Brown, Charles Sidney Vesey	13 Mosley Street, Newcastle-on-Tyne.
	1882 Dec. 5. 1894 Jan. 16.	*Brown, George Cecil Herbert	Broad Sanctuary Chambers, Westminster, S.W. (Postcard, London.)
	1895 May 21. 1904 Jan. 19.	Brown, Harold Henry Lane	Sewerage and Waterworks, Benares, India.
	1879 Dec. 2. 1890 May 20.	*Brown, James Samuel	Consulting Engineer for Railways, Rangoon, Burma.
	1873 Dec. 2. 1882 Feb. 7.	BROWN, John, C.M.G. (*Member of Council.*)	Eng.-in-Chief, Govt. Railways, Cape Town, C.C.
	1889 Dec. 3. 1903 Jan. 20.	Brown, Joseph William ..	Church Square, West Hartlepool.
m	1874 Mar. 3. 1880 May 25.	*Brown, Oswald	32 Victoria Street, S.W. (Acqua, London.)
T ✠	1904 Feb. 2.	Brown, *Sir* Robert Hanbury, K.C.M.G., *Major* R.E. *ret.*	Newlands, Crawley Down, Sussex.
S t ✠	1868 Dec. 1.	Brown, Thomas Forster ..	Springfort, Stoke Bishop, Bristol.
	1901 Apr. 23.	Brown, Westgarth Forster	Guildhall Chambers, Cardiff.
	1864 Dec. 6. 1871 Mar. 7.	Browne, *Sir* Benjamin Chapman, D.C.L. (*Durham*) ..	Hawthorn's Engine Works, Newcastle-on-Tyne.
	1893 Dec. 5. 1903 Dec. 22.	Browning, George Elliot ..	Trichur, South India.
	1896 Feb. 4. 1904 Feb. 23.	Broxup, Charles Thomas ..	Loco. Supt., Railways, Manila, Philippines.
t ✠	1882 Dec. 5. 1894 Feb. 27.	Bruce, Alexander Fairlie	Municipality, Bombay.
T ✠	1850 Apr. 2.	BRUCE, *Sir* George Barclay (*Past-President.*)	3 Victoria Street, S.W. (Brentesia. London.)
	1892 Dec. 6.	Bruce, John	Hill Crest, Whitby.

	Date of Election and of Transfer.	MEMBERS.	
	1891 Feb. 3.	BOLLER, ALFRED PANCOAST, M.A. (*Penn.*)	1 Nassau Street, New York, U.S.
✠	1887 Feb. 1.	BOLTON, ALEXANDER JOSEPH	Calcutta.
	1884 Dec. 2.	BOND, CHARLES JOHN	South Indian Ry., Trichinopoly.
	1884 Feb. 5. / 1896 Nov. 16.	BONN, CARL RODERIQUE LOUIS MENNI	180 Hope Street, Glasgow.
✠	1876 May 2. / 1878 Dec. 31.	BOOTH, ROBERT BELL	Lalpuri, Silchester Road, Glas geary, co. Dublin.
	1891 Feb. 3. / 1901 Dec. 17.	*BORROWMAN, WILLIAM CAMERON	Strathmore, West Hartlepool.
	1878 May 7.	BOSTOCK, JOHN HENRY	Harbour Works, Colombo, Ceylon.
	1879 Feb. 4. / 1892 Nov. 1.	BOSWELL, ST. GEORGE JAMES, B.Sc. (*McGill*)	Harbour Works, Quebec, Canada.
	1877 Feb. 6. / 1897 Mar. 2.	BOTLEY, CHARLES EDWARD ..	Gasworks, Hastings.
	1890 Dec. 2. / 1895 Oct. 22.	BOUCHER, ARTHUR SACKVILLE	Sharpcliffe Hall, Ipstones, Stoke-on Trent.
✠	1874 Feb. 3. / 1878 Apr. 16.	*BOULNOIS, HENRY PERCY ..	Local Government Board, White hall, S.W.
	1886 Jan. 12. / 1896 May 19.	*BOURKE, WALTER LONGLEY ..	Manor House, Elstree, Herts.
	1880 Dec. 7.	BOUSCAREN, LOUIS FREDERICK GUSTAVE	City Hall, Cincinnati, U.S.
✠	1876 Dec. 5. / 1886 May 18.	*BOVEY, HENRY TAYLOR, M.A., LL.D. (*Cantab.*), F.R.S.	McGill University, Montreal, Canad
	1889 Dec. 3. / 1900 Dec. 19.	BOWER, THOMAS	Ribble House, West Hartlepool.
	1876 Apr. 4. / 1881 Feb. 22.	BOWSTEAD, CHARLES JAMES ..	Hyde Grange, Chalford, Glos.
	1882 Apr. 4. / 1894 Oct. 30.	*BOYCE, HENRY GEORGE, F.C.H.	Allahabad, India.
✠	1854 Jan. 10. / 1860 Feb. 14.	BOYLE, RICHARD VICARS, C.S.I.	3 Stanhope Terrace, Hyde Park W.
	1884 Dec. 2. / 1893 May 16.	*BOYNTON, FRANCIS, *Major R.E.*	R. E. Office, Warwick.
	1893 Dec. 5. / 1903 Dec. 22.	*BRADLEY, JAMES WILLIAM ..	City Hall, Charing Cross Road, W.
C t ✠	1883 May 29. / 1895 Jan. 29.	BRADY, ALFRED BARTON ..	Under Secretary, D.P.W., Brisbane Queensland.
	1868 May 5.	BRADY, FRANCIS	12 St. Edmund's Terrace, N.W.
✠	1875 Dec. 7. / 1878 Dec. 3.	BRADY, JOSEPH	367 Collins St., Melbourne, Vi toria.
	1877 May 1.	BRAMALL, HENRY	Pendlebury Collieries, near Ma chester.
	1897 Apr. 6.	*BRAND, ALLEN MASON	G. I. P. Ry., Engineer's Offi [Bomba
Tt Mm ✠	1883 May 28. / 1899 Nov. 28.	*BREBNER, ALAN, B.Sc. (*Edin.*)	Croxton Villa, Eccleshall, Staffs.
	1874 May 5. / 1899 Jan. 10.	[illegible]AN, GEORGE WOULFE ..	Albany Street Chambers, [illegible] N.B.
	1891 Dec. 1.	[illegible]ON, ALFRED, C.S.I. ..	c.o. Grindlay & Co., Parlia[illegible] Street, S.W.
	1880 Feb. 3[illegible]	[illegible]ETON, CUTHBERT [illegible]UR (*Member of Council.*)	21 Delahay St., W[illegible] (Consilium, [illegible] 24.)
	1865 Jan. 1[illegible]	[illegible]ON, ROBERT MAITLAND	Woodsto[illegible]
	1878 Mar. [illegible] / 1885 Feb. [illegible]	[illegible]AND, JOSIAH CORBETT ..	Bra[illegible]
	1901 Feb[illegible]	[illegible], SANTIAGO	[illegible]
	1881 Ma[illegible] / 1891 Ap[illegible]	[illegible]S, JAMES	
	1881 De[illegible] / 1893 N[illegible]	[illegible]GS, JOHN HENRY	

Date of Election and of Transfer.	MEMBERS.	
1896 May 5.	BRIGGS, ROSWELL EMMONS ..	Apartado 561, Mexico.
1889 Dec. 3. / 1896 Nov. 24.	*BRIGHTMORE, ARTHUR WILLIAM, D.Sc. (*Victoria*)	Egham Hill, Egham, Surrey.
1874 Mar. 3.	BRIND, ALFRED WALTER ..	19 Madeley Road, Ealing, W.
1874 May 5. / 1886 Mar. 1.	BRITTLE, JOHN RICHARD, F.R.S.E.	Farad Villa, Vanbrugh Hill, Blackheath, S.E.
1868 Dec. 1.	BROADRICK, GEORGE, F.R.S.E.	Broughton House, Broughton Road, Ipswich.
1865 Feb. 7. / 1877 Mar. 13.	BROCK, WALTER	Denny Brothers, Dumbarton.
1904 Apr. 19.	BROCK, HENRY WILLIAM ..	Denny Brothers, Dumbarton, N.B.
1890 Jan. 14. / 1897 Dec. 7.	BRODIE, JOHN ALEXANDER ..	City Engineer, Liverpool.
1886 Dec. 7. / 1902 Mar. 4.	*BRODIE, ROBERT	17 Priory Street, Birkenhead.
1893 Dec. 5. / 1896 Nov. 24.	BROË, VICTOR EDGAR DE BIRCHIN DE	North Western Railway, Lahore, India.
1871 May 23. / 1889 Nov. 26.	BROMLEY, WALTER BRANDRETH	Chakrata, Brittany Road, St. Leonards.
1883 Jan. 9. / 1889 Nov. 15.	*BROOKHOUSE, ROBERT HAROLD	Calle 25 de Mayo 81, Buenos Aires.
1877 Dec. 4. / 1892 Nov. 15.	BROOM, GEORGE JAMES COTTOM	Boro' Engineer, St. Helens, Lancs.
1876 Jan. 11. / 1885 May 12.	*BROUNGER, RICHARD ERNEST ..	Ferrocarril, San José, Costa Rica.
1885 Dec. 1. / 1904 Jan. 19.	*BROUNGER, SYDNEY GEORGE ..	36 Priory Road, Bedford Park, W.
1890 Feb. 4.	BROWN, ANDREW	Wm. Simons & Co., Renfrew.
1881 May 31. / 1885 Nov. 10.	BROWN, ARTHUR	Guildhall, Nottingham.
1883 Dec. 4. / 1894 Jan. 23.	BROWN, ARTHUR CARDWELL ..	Reconquista 144, Buenos Aires.
1886 Feb. 2. / 1893 Dec. 5.	BROWN, ARTHUR EDWARD ..	Tower House, East Cowes, I.W.
1894 Feb. 6. / 1902 Jan. 28.	*BROWN, CHARLES SIDNEY VESEY	13 Mosley Street, Newcastle-on-Tyne.
1882 Dec. 5. / 1894 Jan. 16.	*BROWN, GEORGE CECIL HERBERT	Broad Sanctuary Chambers, Westminster, S.W. (Postcard, London.)
1895 May 21. / 1904 Jan. 19.	BROWN, HAROLD HENRY LANE	Sewerage and Waterworks, Benares, India.
1879 Dec. 2. / 1890 May 20.	*BROWN, JAMES SAMUEL	Consulting Engineer for Railways, Rangoon, Burma.
1873 Dec. 2. / 1882 Feb. 7.	BROWN, JOHN, C.M.G. (*Member of Council.*)	Eng.-in-Chief, Govt. Railways, Cape Town, C.C.
1889 Dec. 3. / 1903 Jan. 20.	BROWN, JOSEPH WILLIAM ..	Church Square, West Hartlepool.
1874 Mar. 3. / 1880 May 25.	*BROWN, OSWALD	32 Victoria Street, S.W. (Acqua, London.)
1904 Feb. 2	BR[illegible] *Sir* ROBERT HANBURY, [illegible]C.G., *Major* R.E. *ret.*	Newlands, Crawley Down, Sussex.
1869 Dec[illegible]	[illegible] THOMAS FORSTER ..	Springfort, Stoke Bishop, Bristol.
[illegible]	[illegible] WESTGARTH FORSTER	Guildhall Chambers, Cardiff.
[illegible]	[illegible] *Sir* BENJAMIN CHAP-[illegible] D.C.L. (*Durham*) ..	Hawthorn's Engine Works, Newcastle-on-Tyne.
[illegible]	[illegible] GEORGE ELLIOT ..	Trichur, South India.
[illegible]	[illegible] THOMAS ..	Loco. Supt., Railways, Manila, Philippines.
[illegible]	[illegible] FAIRLIE	Municipality, Bombay.
[illegible]	[illegible] BARCLAY [illegible]nt.)	3 Victoria Street, S.W. (Brentesia, London.)
[illegible]	[illegible]	Hill Crest, Whitby.

	Date of Election and of Transfer.	MEMBERS.	
	1886 Apr. 6. 1899 Nov. 28.	*Brundell, Henry Augustus	1 Prince's Street, Doncaster.
	1885 May 19. 1899 Dec. 12.	*Brunlees, Howard	Harratt & Pollock, 27 Ely Place Holborn, E.C.
	1875 Dec. 7. 1878 May 14.	*Brunlees, John	12 Victoria Street, S.W. (West minster 245.)
t ✠	1884 May 27.	Brunton, David William ..	865 Grant Avenue, Denver, Colorado [U.S.
	1884 Jan. 8. 1901 Dec. 11.	*Brunton, James Forrest ..	Municipality, Karachi, India.
✠	1875 Mar. 2. 1879 Mar. 4.	Bryan, William Booth ..	East London Waterworks, Lea Bridge, N.E. (Engineer, Water-works, Clapton.)
	1891 May 12. 1901 Jan. 15.	*Bryant, Ernest Walrond ..	54 Meadow Street, Fort Bombay.
	1878 Feb. 5.	Buchanan, Alexander	Messrs. Handyside & Co., Derby.
✠	1891 Feb. 3. 1899 Dec. 12.	*Buchanan, George Cunning-ham	Chairman, Port Trust, Rangoon, Burma.
	1891 Jan. 13.	Buchanan, William	160 West 87th Street, New York, U.S.
t ✠	1898 Dec. 6.	Buck, Leffert Lefferts ..	Hastings on Hudson, New York, U.S.
	1871 Apr. 4. 1887 Jan. 25.	Buckham, Edward	Town Hall, Ipswich.
✠	1873 Dec. 2. 1880 Nov. 2.	Buckley, Robert Bupton, C.S.I.	44 Clanricarde Gardens, Bayswater, W.
	1879 Apr. 1.	Budge, Enrique	Valparaiso, Chile. [Argentina.
	1888 Dec. 4.	Budge, Oliver	East Argentine Ry., Concordia,
	1873 May 6. 1879 Nov. 4.	Bulkley, Thomas Alfred ..	Penyllan Hall, Meifod, Welshpool.
	1875 Dec. 7. 1889 Apr. 16.	Bulmer, Philip	37 The Avenue, Sunderland.
	1886 Apr. 6. 1894 Nov. 27.	Burch, William	Admiralty Office, H.M. Dockyard Extension, Keyham, Devonport.
T t ✠	1866 Mar. 6. 1878 Apr. 9.	Burge, Charles Ormsby ..	Railway Construction Branch, P.W.D., Sydney, N.S.W.
	1888 Dec. 4. 1899 Apr. 18.	*Burgess, Samuel Edwin ..	Boro' Engineer, South Shields.
✠	1871 May 23. 1883 May 1.	*Burke, Charles Toler ..	School Board, Sir Thomas Street, Liverpool.
	1872 Dec. 3. 1883 Mar. 20.	Burke, George John	37 Brighton Rd., St. Kilda, Victoria.
	1887 Dec. 6.	Burke, James Marlow	G. S. & W. Ry., Cork. (Burke, Cork.)
	1893 Dec. 5. 1902 Apr. 8.	*Burn, George Frank	9 Great George Street, S.W.
	1903 Mar. 3.	Burnet, Farie	Assist. Engr.-in-Chief, Table Bay Harbour Works, Cape Colony.
	1886 Dec. 7. 1896 Feb. 25.	Burnett, James	Ry. Dept., Wellington, N.Z.
	1866 Feb. 6. 1871 May 2.	Burnett, Robert Harvey ..	Gorton Foundry, Manchester.
	1884 Feb. 5. 1889 Mar. 12.	Burr, William Henry ..	El Rancho, F.C. del Norte, Guatemala.
✠	1893 Dec. 5.	Burr, William Hubert ..	Columbia College, New York, U.S.
	1902 Dec. 2.	Burrows, Thomas Edward ..	Harbours and Rivers Branch, P.W.D., Sydney, N.S.W.
	1876 May 2. 1881 Jan. 11.	*Burstal, Edward Kynaston	38 Parliament Street, S.W. (Hole-meter, London.)
	1892 Dec. 6. 1900 Dec. 18.	Burstall, *Professor* Henry Frederic William, M.A. (*Cantab.*)	Mason University College, Birmingham.
	1888 Dec. 4. 1897 Mar. 2.	*Burstall, Henry Robert John	14 Old Queen St., Westminster, S.W.
	1887 Apr. 5. 1894 Feb. 27.	*Bury, Oliver Robert Hawke	General Manager, G.N.Ry., King's Cross, N.

	Date of Election and of Transfer.	MEMBERS.	
	1874 May 12.	BUSH, GEORGE	110 Cannon Street, E.C.
	1894 Dec. 4. 1908 Jan. 20.	BUSH, ROBERT, B.A. (*Oxon.*)	Dockyard, Liverpool.
	1898 Dec. 6.	BUSH, THOMAS JAMES	Australian Gas Co., Sydney, N.S.W.
✠	1885 Apr. 14. 1893 Nov. 7.	BUTLER, MATTHEW JOSEPH	Locomotive Co. of Montreal, 75 Notre Dame Street, Maisonneuve, P.Q., Canada.
	1875 Dec. 7.	BUTLER, WALTER	Witham, Essex.
	1874 May 5. 1904 Feb. 2.	BUTLER, WILLIAM FREDERIC	14 Nicholas Street, Chester.
	1888 Dec. 4. 1898 Nov. 29.	BUTLER, *Professor* WILLIAM ROBERT, M.E. (*King's Coll., Nova Scotia.*)	Royal Military College, Kingston, Ontario, Canada.
m ✠	1881 Apr. 5.	BUTTER, HENRY JOSEPH	Claremont, Burrage Rd., Plumstead.
	1888 Dec. 4. 1895 Jan. 8.	BUTTON, FRED SMITH	Blannel Street, Burnley.
	1900 Apr. 3.	CAIRD, ROBERT, LL.D. (*Glas.*)	Greenock, N.B.
✠	1892 Dec. 6. 1900 Dec. 18.	CALLAWAY, HUGH	J. I. Thornycroft & Co., Chiswick, W.
	1900 Dec. 4.	CALTHROP, EVERARD RICHARD	3 Crosby Square, E.C. (Raillerait. London. Avenue 4360.)
	1892 Apr. 5.	CAMARA, ANTONIO DE LA	Calle Marmoles 6, Seville, Spain.
	1881 Dec. 6.	CAMERON, EDWARD ALEXANDER	The Towers, College Road, Buxton.
	1887 Dec. 6. 1904 Mar. 15.	*CAMPBELL, ADAM HORSBURGH	Town Hall, East Ham, E.
	1887 Apr. 5. 1900 Jan. 23.	CAMPBELL, KENNETH FINDLATER	Borough Engineer, Huddersfield.
	1868 Dec. 1. 1889 Apr. 30.	CAMPBELL, THOMAS PROCTER	Dalhousie, Punjab.
	1872 Dec. 3. 1885 Feb. 24.	*CAMPION, JOHN MONTRIOU	Kufri, Amherst Road, Ealing, W.
	1876 Feb. 1.	CANNING, *Sir* SAMUEL	1 Inverness Gardens, Kensington, W.
m ✠	1890 Jan. 14. 1898 Nov. 29.	*CAPPER, *Professor* DAVID SING, M.A. (*Edin.*)	King's College, Strand, W.C. (Westminster 5255.)
	1863 Dec. 1. 1888 Apr. 17.	CARBUTT, *Sir* EDWARD HAMER, *Bart.*	19 Hyde Park Gardens, W.
	1886 Feb. 2. 1896 Mar. 31.	CARDEW, CORNELIUS EDWARD	Burma Rys. Co., Insein, Burma.
✠	1877 Dec. 4. 1884 Dec. 23.	*CAREY, ALFRED EDWARD	110 Fenchurch Street, E.C. (Foreshore, London.)
	1870 Apr. 5. 1877 Nov. 27.	CARGILL, THOMAS, B.A. (*Dubl.*)	E. E. Brook, 4 King's Bench Walk, Temple, E.C.
	1878 May 7. 1896 Dec. 22.	*CARLESS, GEORGE PROCTER	Trevenna, Furze Platt, Maidenhead.
	1866 Mar. 6.	CARLILE, HUGH	6 Kandauerstrasse, Riga.
	1883 Dec. 4. 1888 Feb. 14.	CAROLIN, EDWARD RICHARD	District Engineer, Govt. Railways, Cape Town, C.C.
✠	1886 Apr. 6. 1896 Mar. 17.	CARPENTER, CHARLES CLAUDE	South Metropolitan Gasworks, 709A Old Kent Road, S.E.
	1892 Jan. 12. 1898 Dec. 20.	CARR, ISAAC	Gas and Waterworks, Widnes.
	1875 May 4. 1884 Mar. 4.	CARR, MARK WILLIAM	Bella Vista, Cimiez, Nice, France.
	1891 Apr. 7. 1901 Apr. 23.	*CARR, ROBERT ALFRED	1 West Pier, London Docks, E.
t ✠	1875 Dec. 7. 1881 Nov. 29.	CARRINGTON, WILLIAM THOMAS HENNEY	72 Mark Lane, E.C.

	Date of Election and of Transfer.	MEMBERS.	
	1869 May 11. 1877 Jan. 23.	CARROLL, EDWARD BROTHERTON	Huntington, Ottershaw, Surrey.
✠	1866 Jan. 9. 1871 May 16.	CARRUTHERS, JOHN	13 Victoria Street, S.W.
	1896 Dec. 1.	CARSON, HOWARD ADAMS ..	Malden, nr. Boston, Mass., U.S.
t ✠	1876 Dec. 5.	CARSON, WILLIAM	Bryn Estyn, Chester.
	1876 Feb. 1. 1887 Jan. 25.	CARTER, WILLIAM ALLAN ..	14 Queen Street, Edinburgh. (Com- pass, Edinburgh. 1594.)
	1878 Feb. 5. 1884 Mar. 18.	CARTWRIGHT, GEORGE	Great Central Ry., Grimsby Docks [Lanc
	1875 Dec. 7. 1885 Jan. 20.	CARTWRIGHT, JOSHUA	Peel Chambers, Market Place, Bury
m	1884 Feb. 5. 1893 Dec. 5.	*CASE, ALBERT HAVELOCK ..	Broad Sanctuary Chambers, West- minster, S.W.
✠	1872 Apr. 9. 1891 Apr. 7.	*CASH, JOSEPH	Gas Co., Hove, Brighton.
	1902 Feb. 4.	CASSON, ARTHUR WILLIAM HENRY	G.C.Ry., Elm Road, Wembley.
	1868 Dec. 1.	CATO, ALEXANDER	St. Macaire, Gironde, France.
	1900 Mar. 6.	CATT, GEORGE WILLIAM ..	Park Row Building, New York City U.S.A.
	1879 Mar. 4. 1887 May 24.	CAULFEILD, FRANCIS JOHN ROTHE TOBY ST. GEORGE, I.S.O.	Taiping, Perak, S.S.
	1902 Jan. 14.	CAVENDISH, WILLIAM HASTINGS, B.Sc. (*Victoria*)	S. Pearson & Son, 10 Victoria Street S.W.
✠	1864 Mar. 1. 1872 Apr. 16.	CAY, WILLIAM DYCE, F.R.S.E.	1 Albyn Place, Edinburgh.
	1878 May 7. 1884 Nov. 4.	CHADWICK, GEORGE BURTON ..	c.o. London and County Bank Brighton.
✠	1872 Jan. 9. 1897 Nov. 30.	CHADWICK, OSBERT, C.M.G...	7 Carteret Street, Westminster, S.W.
	1889 Dec. 3. 1899 Nov. 28.	CHALCRAFT, GEORGE BARKER	The Green, Dore, Sheffield.
✠	1879 Dec. 2. 1884 Jan. 22.	CHAMIER, GEORGE	Mercantile Bank Chambers, Mar- garet Street, Sydney, N.S.W.
	1882 May 23. 1893 Feb. 21.	*CHANTER, FRANCIS WILLIAM ..	C. E. R. Chanter, Bridge Chambers Barnstaple.
	1875 Mar. 2. 1878 Jan. 15.	CHAPMAN, ALFRED	Fawcett, Preston & Co., 17 York Street, Liverpool.
	1872 Feb. 6. 1879 Jan. 14.	CHAPMAN, HENRY	69 Victoria Street, S.W.
	1900 Dec. 4.	CHAPMAN, HENRY BENJAMIN HOGHTON	Boskenna, Shirehampton, Bristol
	1879 Feb. 4. 1894 May 22.	CHAPMAN, JOSEPH CRAWHALL	Cadewell, near Torquay.
	1864 Jan. 12.	CHAPMAN, ROBERT	Mon Abri, Alington Rd., Lansdowne Park, Bournemouth.
	1892 Mar. 1. 1903 Dec. 22.	*CHARTERS, ROBERT HEARN ..	Box 590, Cape Town, C.C.
	1894 Jan. 9.	CHASE, LLOYD HEBER	New Bridge Works, Runcorn.
✠	1885 Feb. 3. 1897 Nov. 30.	*CHATHAM, WILLIAM	Director of Public Works, Hong- kong.
	1883 Feb. 6.	CHATTERJEE, *Rai Bahadur* KHETTER NAUTH	Gustia, *vid* Baraset, Calcutta.
m ✠	1879 Feb. 4. 1883 Nov. 27.	*CHATTERTON, GEORGE, M.A. (*Dubl.*)	6 The Sanctuary, Westminster S.W.
	1886 Feb. 2. 1891 May 12.	CHEESEWRIGHT, FREDERICK HENRY	4 Park View Terrace, Wimbledon Park Road, S.W.
✠	1882 May 23. 1898 Apr. 26.	CHENHALL, JAMES WARNE ..	Dart Villas, Totnes. (Chenhall Totnes.)
	[illegible]9 May 21. [illegible]3 Dec. 22.	CHILD, WILLIAM SAMUEL ..	Harbour Engineer, Aden.

	Date of Election and of Transfer.	MEMBERS.	
✠	1887 Jan. 11. 1896 Dec. 15.	CHILDE, HENRY SLADE	Wakefield. (Childe, Wakefield, 3.)
	1880 May 25.	CHORLTON, JOHN SAMUEL ..	The Rookery, Chatburn, Clitheroe.
	1847 Mar. 2. 1873 Dec. 23.	CHRISTY, FREDERICK COLLIER	St. Cyr, William St., South Yarra, Melbourne, Victoria.
	1894 Dec. 4.	CHROCKATT DE SA PEREIRA DE CASTRO, JOÃO	Rua das Larangeiras 202, Rio de Janeiro.
	1896 May 19.	CHUBB, THOMAS LYON	Western Railway, Buenos Aires.
	1875 Feb. 2.	CHURCH, RICHARD FREDERICK	20 Victoria Street, S.W. (Westminster, 252.)
	1878 Jan. 15. 1897 Apr. 6.	*CHURCHWARD, GEORGE DUNDAS	Trefusis, Cary Avenue, St. Marychurch, Torquay.
	1897 Feb. 2. 1903 Dec. 22.	CHURCHWARD, GEORGE JACKSON	Newburn, Swindon.
	1898 Dec. 6.	CLARK, CHARLES COSBY STEWART	c.o. Thos. Cook & Son, Ludgate Circus, E.C.
	1895 Dec. 3. 1897 Dec. 7.	CLARK, EDWIN KITSON, M.A. (*Cantab.*)	Airedale Foundry, Leeds.
	1904 Jan. 12.	CLARK, LYONEL EDWIN	11 Victoria Street, S.W.
	1890 Mar. 4. 1892 Nov. 22.	*CLARKE, GEORGE JAMES.. ..	Tees Conservancy, Middlesbrough.
	1888 Apr. 10. 1896 Feb. 25.	*CLARKE, JOSEPH PERCIVAL ..	Leopoldina Ry., Caixa 291, Rio de Janeiro.
	1866 May 15.	CLARKE, WILLIAM	39 Old Queen Street, Westminster, S.W.
	1888 Dec. 4. 1901 Dec. 11.	CLARKE, WILLIAM JOHN.. ..	H.M. Dockyard, Devonport.
	1884 Jan. 8.	CLAYTON, THOMAS GETHING ..	The Grange, Normanton, Derby.
	1892 May 3. 1903 Apr. 7.	CLEGHORN, ALEXANDER.. ..	10 Whittingehame Drive, Kelvinside, Glasgow.
	1887 Dec. 6.	CLEMENT, LEWIS METZLER ..	Haywards, Alameda County, Cal., U.S.
✠	1884 Apr. 1. 1902 Dec. 16.	CLEMES, JOHN HENRY	The Bracken, Newquay, Cornwall.
W t ✠	1889 Jan. 8. 1899 Dec. 12.	CLERK, DUGALD	18 Southampton Buildings, Chancery Lane, W.C. (Abecedary, London. Holborn, 836.)
✠	1888 Dec. 4. 1900 Apr. 10.	*CLIFTON, COURTENAY THORNTON	Ministry of Public Works, Cairo.
	1893 Dec. 5. 1901 Feb. 19.	*CLIRREHUGH, STAMFORD VAIR..	4 Queen Victoria Street, E.C.
	1877 Dec. 4. 1898 Nov. 29.	CLOUGH, CHARLES FREDERIC..	7 Daleham Gardens, S. Hampstead, N.W.
	1875 Dec. 7. 1888 Mar. 13.	COATES, JOHN	Suffolk House, Laurence Pountney Hill, E.C.
	1877 Jan. 16. 1890 May 6.	*COBLEY, WALTER HENRY ..	Govt. Rys., Maritzburg, Natal.
	1883 Feb. 6.	COCHRANE, CHARLES STYLE ..	Port of Spain, Trinidad.
✠	1890 Feb. 4. 1899 Feb. 14.	COCKRILL, JOHN WILLIAM ..	Boro' Engineer, Great Yarmouth.
	1866 Feb. 6. 1872 Jan. 23.	CODRINGTON, THOMAS	5 Riverdale Rd., Twickenham Park.
	1891 Feb. 3. 1903 Dec. 22.	COE, DAVID	F. C. Nacional, Tehuantepec, Mexico.
	1894 Feb. 6. 1897 Apr. 6.	COKE, GEORGE ELMSLEY ..	65 Station Street, Nottingham. (Mining, Nottingham.)
	1889 May 3. 1892 Jan. 26.	COLAM, WILLIAM NEWBY ..	57 Henderson Row, Edinburgh. (Colam, Edinburgh.)
	1904 Jan. 12.	COLE, HENRY AYLWIN BEVAN	50 Lime Street, E.C.
✠	1892 Jan. 12 1895 May 14	*COLE, WILLIAM HENRY ..	10 Argyll Mansions, Addison Bridge, Kensington, W.
	1891 Mar. 3.	COLEBROOK, HENRY WILLIAM VAUGHAN	c.o. H. S. King & Co., Pall Mall, S.W.

	Date of Election and of Transfer.	MEMBERS.	
✠	1877 Dec. 4. / 1890 Dec. 16.	COLES, HENRY JAMES	London Crane Works, Derby.
	1886 Mar. 2.	COLLARD, ROBERT	Orchard Leigh, St. John's, Ipswic
	1899 Dec. 5.	COLLEDGE, FRANCIS STEEL ..	109 Bath Street, Glasgow.
	1894 Mar. 6. / 1898 Nov. 29.	COLLEN, WILLIAM, M.A., B.A.I. (*Dubl.*)	County Surveyor, 9 Hume Stre Dublin.
	1898 Mar. 1.	COLLET, HAROLD VAN BRIENAN	Hulburd Engineering Co., 15 Leadenhall Street, E.C. (Un wavering, London. Avenue 444
	1887 Dec. 6. / 1901 Feb. 19.	COLLIN, ALFRED JONES	Wynthorne, Oswestry.
T t ✠	1881 Feb. 1.	COLLINGWOOD, FRANCIS	Elizabeth, New Jersey, U.S.
	1880 Dec. 7. / 1895 Mar. 5.	*COLLINGWOOD, WILLIAM	Vulcan Foundry, Newton-le Willows, Lancs.
	1887 Dec. 6. / 1899 Feb. 28.	COLLINS, ARTHUR ELLISTON ..	City Engineer, Norwich.
✠	1884 May 6. / 1892 Jan. 11.	COLLINS, ERNEST	Wedderburn Road, Hampstead, N.W
	1899 Mar. 7.	*COLLINSON, ALFRED HOWE ..	
	1882 Dec. 5.	COLLISTER, JOHN GEORGE HENRY	G. I. P. Railway, Bombay.
	1876 Mar. 7. / 1889 Apr. 9.	COLSON, ALFRED	Gas Offices, Leicester.
t ✠	1871 Feb. 7. / 1884 Mar. 11.	COLSON, CHARLES, C.B.	Admiralty, 47 Victoria Street, S.W.
✠	1890 Feb. 4. / 1901 Feb. 12.	*COLSON, CHARLES HENRY ..	2 Sternhold Avenue, Streatham Hill, S.W.
	1893 Dec. 5. / 1904 Apr. 19.	*COLVIN-SMITH, HARRY COLVIN	5 Cresswell Gardens, S. Kensington S.W.
	1870 May 24. / 1877 Mar. 27.	COLYER, FREDERICK	41 Old Queen Street, Westminster S.W.
	1897 Dec. 7.	COMBER, PATRICK FORSTALL	19 Lower Leeson Street, Dublin.
W t ✠	1883 May 29. / 1895 Oct. 22.	COMMANS, ROBERT EDDEN ..	6 Queen Street Place, E.C. (Adelaide, London. Bank 828.)
	1883 Dec. 4. / 1893 Mar. 21.	*CONGREVE, HUBERT	Ship Canal Co., 41 Spring Garden Manchester.
	1884 May 6. / 1891 Mar. 24.	CONNAL, EBEN	Midland & S.W. Junction Railway Cirencester.
	1891 Dec. 1. / 1898 Dec. 6.	CONNERY, DANIEL, M.E. (*Queen's*)	Walker, Price and Reeves, 15 Great George Street, S.W.
	1902 Mar. 4.	CONNETT, ALBERT NEUMANN ..	22a College Hill, E.C.
	1870 Dec. 6. / 1883 Mar. 13.	*COODE, JOHN CHARLES	9 Victoria Street, S.W. (Peales London. Westminster 47.)
	1886 Dec. 7. / 1896 Jan. 28.	COODE, MONTGOMERY PENROSE	Rangoon, Burma.
	1894 May 1.	COOK, DAVID	165 Queen Victoria Street, E.C.
	1887 Dec. 6.	COOK, GEORGE LESLIE	P.W.D., Dunedin, Otago, N.Z.
✠	1889 Feb. 5. / 1895 May 14.	COOK, WALTER EDMUND.. ..	Water and Sewerage Dept., Pitt St Sydney, N.S.W.
	1893 Jan. 10.	COOM, JOHN	Ry. Department, Wellington, N.Z.
	1884 May 27. / 1901 Feb. 19.	*COOMBS, CHARLES JOHN PLUMBE, B.A. (*Lond.*) ..	Cedar Lodge, Plympton, Devon
✠	1880 May 25. / 1899 Mar. 28.	*COOPER, CHARLES HAMLET ..	Council Offices, Wimbledon.
	1885 Dec. 1. / 1894 Mar. 13.	*COOPER, FRANCIS ALFRED, C.M.G.	Director of Public Works, Colombo Ceylon.
	1885 Feb. 3.	COOPER, FREDERICK EASTMENT	11 Victoria Street, S.W.
	1895 Dec. 3. / 1903 Apr. 21.	COOPER, RICHARD EDWARD SYNGE	L. B. & S. C. Ry., 328 Queen's Road Battersea, S.W.
	1870 May 3. / 1876 Jan. 11.	COOPER, ROBERT ELLIOTT- (*Member of Council.*) ..	8 The Sanctuary, S.W.
	1876 Mar. 7.	COPLAND, WILLIAM ROBERTSON	146 West Regent St., Glasgow (Copland, Glasgow. 358.)

Date of Election and of Transfer.	MEMBERS.	
✠ 1875 Jan. 12. 1880 Feb. 24.	COPPERTHWAITE, HAROLD ..	Holgate Road, York.
t ✠ 1896 May 19. 1900 Feb. 27.	COPPERTHWAITE, WILLIAM CHARLES	Santa Marta, Beaconsfield Road, Westcombe Park, S.E.
1881 Feb. 1.	CORNISH, JOSIAH EASTON, C.M.G.	Water Co., Alexandria, Egypt.
t ✠ 1884 Dec. 2.	CORTHELL, ELMER LAWRENCE, M.A., D.Sc. (*Brown Univ., Providence, R.I., U.S.*) ..	1 Nassau Street, New York, U.S. (Tabanque, New York.)
1883 Feb. 6. 1899 Feb. 28.	*COSTE, JEAN LOUIS NAPOLEON	P.W.D., Ottawa, Canada.
1887 Apr. 5. 1903 Dec. 22.	*COTTERELL, ALBERT PLAYER ISAAC	28 Baldwin Street, Bristol.
1881 May 31. 1889 Dec. 3.	COTTON, CHARLES OSWELL ..	The Rowans, Abergavenny.
1893 Feb. 7.	COTTON, FRANCIS MICHAEL ..	Harbour Office, Holyhead.
1898 Dec. 6.	COTTON, WILLIAM FRANCIS, Jun.	Alliance and Dublin Gas Co., D'Olier Street, Dublin.
1874 Jan. 13. 1890 May 6.	COTTON, WILLIAM GORDON LYNCH	5 Council House Street, Calcutta.
✠ 1889 May 21. 1895 Mar. 26.	*COTTRELL, STEPHEN BUTLER	Overhead Railway, James Street, Liverpool.
1890 Feb. 4. 1902 Feb. 11.	*COUCHMAN, FRANCIS DUNDAS	King, King & Co., Bombay.
✠ 1894 May 22.	COURTNEY, CHARLES FREDERICK	Sulphide Corporation, 34 Queen Street, Melbourne, Victoria.
1876 May 30. 1889 Nov. 26.	*COURTNEY, FRANK STUART ..	38 Croxted Road, Dulwich, S.E.
✠ 1888 Dec. 4.	COWAN, DAVID	Clevedon, Cove, Dumbartonshire.
m ✠ 1887 May 3. 1904 Mar. 29.	*COWAN, EDWARD WOODROWE .	West Bank, Disley, Cheshire.
1883 Mar. 6.	COWAN, McTAGGART	33 Drummond Place, Edinburgh.
m ✠ 1885 Feb. 3. 1892 May 3.	*COWAN, PETER CHALMERS, B.Sc. (*Edin.*)	33 Ailesbury Road, Dublin.
1894 Dec. 4. 1904 Apr. 19.	COX, ALEXANDER GEORGE ...	c.o. H.B.M. Consul, Tientsin, China.
1880 Dec. 7. 1889 Dec. 3.	COX, JOHN HENRY	City Surveyor, Bradford.
1883 May 29. 1900 Dec. 18.	CRABTREE, WILLIAM HENRY ROBINSON	20 Thorne Road, Doncaster.
1880 May 4. 1883 Nov. 6.	CRAIG, JOHN, M.A. (*Dubl.*) ..	East London, Cape Colony.
t ✠ 1861 Apr. 9. 1879 Nov. 11.	CRAWFORD, *Professor* ROBERT, M.A.I. (*Dubl.*	Stonewold, Ballyshannon, Ireland.
1888 Dec. 4. 1893 Mar. 7.	CRAWFORD, ROBERT	Harbour Engineer, Greenock, N.B.
1896 May 5.	CRAWFORD, WILLIAM	Dept. Rys. and Canals, Ottawa, Canada.
1877 Feb. 6. 1883 May 29.	CRAWFURD, JOHN BRUCE ..	72 Cambridge Street, Pimlico, S.W.
1881 Mar. 1. 1898 Mar. 22.	CREASY, LEONARD	P.W.D., Kandy, Ceylon.
1879 Feb. 4. 1884 Dec. 23	CRESWELL, ROBERT EDWARD ..	Te Horo, Wellington, N.Z.
1888 Mar. 6.	CRIGHTON, CHARLES EDWIN ..	10 Albany Villas, Hove.
1899 Dec. 5. 1903 Dec. 22.	CROASDAILE, JOHN ERNEST, M.A., B.A.I. (*Dubl.*) ..	3 Shanganagh Terrace, Killiney, co. Dublin.
1882 Mar. 7.	CROES, JOHN JAMES ROBERTSON	68 Broad Street, New York, U.S.
1889 Dec. 3. 1899 Nov. 28.	CROFTS, CHARLES JAMES ..	Harbour Dept., Port Natal.
Γ t ✠ 1886 May 18.	CROMPTON, ROOKES EVELYN BELL, C.B., *Lt.-Col. Electrical Engs. R.E. (Vols.) (Member of Council.)*	Thriplands, Kensington Court, W.

	Date of Election and of Transfer.	Members.	
	1879 Mar. 4. 1897 Nov. 30.	*Crook, Henry Tipping ..	9 Albert Square, Manchester.
	1892 Feb. 2. 1894 May 22.	Crosland, James Foyell Lovelock	67 King Street, Manchester.
	1886 Feb. 2. 1891 Jan. 13.	Cross, William	Simpson, Strickland & Co., Dartmouth.
	1868 Jan. 14. 1887 Dec. 13.	Crosthwait, Thomas Philip Sherrard, B.A. (*Dubl.*) ..	Shalimar, Mount Eden Rd., Donnybrook, Dublin.
	1871 Feb. 7.	Crouch, William	53 Bothwell Street, Glasgow (Crouch, Glasgow.)
	1868 Apr. 7. 1879 Jan. 7.	Croudace, Charles Hutton	c.o. H. S. King & Co., Pall Mall, S.W.
	1893 May 2.	Crowell, Foster, M.C.E. (*Polytechnic Coll. Penn.*) ..	18 Broadway, New York, U.S. (Budial, New York.)
	1878 May 7. 1893 Mar. 21.	Crowther, George Henry ..	Huddersfield.
	1867 Feb. 5.	Crozier, William	Weaponness Valley, Scarborough.
S t ✠	1883 Feb. 6. 1888 Mar. 13.	Cruttwell, George Edward Wilson	21 Delahay Street, Westminster S.W. (Cruttwell, London. Westminster 24.)
t ✠	1860 May 1.	Cudworth, William	Upperthorpe, Darlington.
✠	1883 Mar. 6. 1896 Jan. 7.	CUDWORTH, William John (*Member of Council.*) ..	Eng.'s Office, N. E. Ry., York.
✠	1895 Feb. 5. 1902 Dec. 16.	Cullen, Edward Alexander	Harbours and Rivers Dept., Brisbane, Queensland.
	1881 Dec. 6. 1899 Dec. 12.	Culverwell, George Parnall, B.A. (*Dubl.*) ..	County Down Ry., Belfast.
	1897 Jan. 12.	Cunha, Ernesto Antonio Lassance	General Lassance, 22 Rua José Bonifacio, Nictheroy, Rio de Janeiro.
✠	1878 Dec. 3.	Cuningham, Granville Carlyle	Central London Ry., 125 High Holborn, W.C.
	1868 Dec. 1. 1873 Apr. 1.	Currey, Eliott Scarlett ..	Fachlwyd Hall, Cyffylliog, Ruthin.
m	1877 Dec. 4. 1886 Jan. 19.	*Curry, *Professor* Matthew ..	King's College, Strand, W.C.
	1891 Apr. 7.	*Curry, Thomas Elmitt ..	18 Canning Road, Croydon.
	1883 Apr. 3.	Cuthbert, Edwin	Drainage Board, Christchurch, N.Z.
	1888 Dec. 4. 1896 Apr. 21.	D'Arth, John	P.W. Office, Kingston, Jamaica.
	1876 May 2.	Daglish, George Heaton ..	Rock Mount, Aigburth, Liverpool (Daglish, Aigburth, Liverpool 2717.)
✠	1894 Jan. 9. 1898 Nov. 29.	Dalby, *Professor* William Ernest, M.A. (*Cantab.*), B.Sc. (*Lond.*)	Technical College, Finsbury, E.C.
	1887 Dec. 6. 1899 Mar. 28.	*Dalrymple - Hay, Harley Hugh	Underground Electric Rys. Co., Hamilton House, Victoria Embankment, E.C.
	1899 Dec. 5.	d'Alton, Patrick Walter ..	Dick, Kerr & Co., 110 Cannon Street, E.C.
	1881 May 31.	Danby, William	Hong Kong.
	1871 Mar. 7.	Dangerfield, Edward	40 Central Hill, Upper Norwood, S.E.
	7	Darby, John Henry	Brymbo Hall, near Wrexham.
	2.	DARLEY, Cecil West, I.S.O. (*Member of Council.*)	N.S.W. Government Office, 9 Victoria Street, S.W.
	.	Dartnall, William Whitney	Perth, Western Australia.
		Davey, Henry	3 Princes Street, Westminster, S.W.

Date of Election and of Transfer.	MEMBERS.	
1884 May 6.	DAVIDSON, JAMES YOUNG ..	Stowe Lodge, Elm Grove, Wimbledon, S.W.
1876 Dec. 5. 1885 Dec. 1.	DAVIDSON, ROBERT	37 Surrey Street, Sheffield.
1888 May 1. 1899 Dec. 5.	DAVIES, HARRY SEAGRAVE ..	Agency Engineer, Rajkot, Kathiawar, India.
1884 May 6.	DAVIES, WILLIAM	The Celyn, Caergwrle, Wrexham.
1882 May 2. 1904 Mar. 29.	*DAVIS, ALFRED THOMAS ..	County Surveyor, Shrewsbury.
1866 May 15.	DAVIS, HENRY WHEELER ..	5 Highbury Grove, N.
✠ 1889 Dec. 3. 1891 Nov. 9.	DAVIS, JOSEPH	Sewerage Dept., Sydney, N.S.W.
✠ 1884 Mar. 4. 1895 Jan. 22.	*DAVISON, ROBERT COPE HARDY	25 Victoria Street, S.W. (Groyne, London. Westminster 5170.)
1866 Dec. 4. 1872 Mar. 27.	DAWSON, GEORGE JAMES CROSBIE	North Staffs. Ry., Stoke-on-Trent.
1886 Jan. 12. 1896 Feb. 25.	*DAWSON, WILLIAM	L. & N. W. Ry., Crewe.
1886 Mar. 2. 1896 Feb. 25.	DAWSON, WILLIAM	Town Hall, Leyton, E.
1878 Feb. 5. 1884 Jan. 8.	*DAWSON, WILLIAM ALFRED ..	1 Victoria Street, S.W.
1883 Mar. 6.	DAY, ARTHUR JAMES	Northam Iron Works, Southampton.
1871 Jan. 10.	DAY, JAMES EDWARD	Violet Hill, Ballybrack, co. Dublin.
t ✠ 1872 Dec. 3. 1874 Jan. 6.	DEACON, GEORGE FREDERICK LL.D. (*Glas.*) (*Member of Council.*)	16 Great George Street, S.W. (Vyrnwy, London. Victoria 1486.)
1886 Dec. 7. 1892 Dec. 20.	DEACON, MAURICE	Whittington House, nr. Chesterfield.
1877 Mar. 6. 1878 Jan. 15.	DEAN, WILLIAM	10 Terlingham Gardens, Folkestone.
✠ 1874 May 5. 1886 May 11.	DEANE, HENRY, M.A. (*Royal*) ..	Ry. Dept., Sydney, N.S.W.
1895 Dec. 3.	DEANE, HENRY HARGRAVE, B.A. (*Dubl.*)	B. B. & C. I. Ry., Bombay.
1886 Apr. 6. 1894 Feb. 20.	DE BRATH, STANLEY	Preston House School, Bookham, Surrey.
✠ 1888 May 15. 1894 Nov. 20.	DE BURGH, ERNEST MACARTNEY	Greystones, co. Wicklow.
1868 Feb. 4.	DENHAM, CHARLES HENRY ..	Taljeriah, Craneswater, Southsea.
1886 Dec. 7. 1908 Jan. 13.	*DENISON, ALBERT	Victoria, Hong Kong.
1889 Mar. 5.	DENNISON, GAVIN HADDEN ..	The Firs, Meadowbank, Oamaru, N.Z.
1900 Apr. 3.	DENNY, ARCHIBALD	Leven Ship-Yard, Dumbarton, N.B.
1863 Apr. 14.	DENT, WILLIAM DENT, M.A. (*Cantab.*)	5 Greenheys Road, Princes Park, Liverpool.
1891 Dec. 1.	DENTON, EARDLEY BAILEY, B.A. (*Oxon.*)	9 Bridge Street, Westminster, S.W.
t ✠ 1868 Feb. 4. 1893 May 9.	DE RUSETT, EDWIN WILLIAM	Warden House, Tynemouth.
✠ 1902 Apr. 22.	DEUCHARS, GEORGE, F.C.H. ..	Thos. Cook & Son, Bombay.
1888 Mar. 2. 1900 Apr. 3.	DEVERELL, THOMAS CLARK ..	Durban, Natal.
t ✠ 1884 Mar. 4. 1899 Nov. 28.	*DEWRANCE, JOHN	Cranmore Place, Chislehurst.
1888 Apr. 10. 1893 May 2.	DICK, FREDERICK JOHN	Office of Public Works, Dublin.
1877 Feb. 6. 1881 Nov. 15.	DICK, GAVIN GEMMELL	Queensland Office, 1 Victoria Street, S.W.
✠ 1889 May 7. 1903 Apr. 7.	DICKINSON, ALFRED	Telephone Buildings, Birmingham. (Traction, Birmingham.)
1860 Apr. 3.	DICKINSON, JAMES AUSTEN ..	8 Crosthwaite Park, Kingstown, co. Dublin.

	Date of Election and of Transfer.	MEMBERS.	
	1895 Mar. 5. / 1901 Dec. 11.	DICKSON, NORMAN BONNINGTON	Leopoldina Ry., Rio de J
	1880 Apr. 6.	DILLON, JAMES	36 Dawson Street, Dublin.
	1892 Feb. 2. / 1894 Nov. 27.	DIXON, EDWARD KEVILLE, M.E. (*Royal*)	County Surveyor, Ca
	1895 Mar. 5. / 1899 Nov. 28.	DIXON, EDWARD WILSON ..	Waterworks Engineer, H
	1891 May 12.	DIXON, FREDERICK PARKER ..	Town Hall, Rathmines, co.
	1878 Feb. 5. / 1882 Nov. 27.	DIXON, WAYNMAN	Cleveland Dockyard, Middle (Dixon, Middlesbrough.)
T t ✠	1842 Mar. 1. / 1881 Mar. 29.	DOBSON, EDWARD	Hereford St., Christchurch,
t ✠	1873 Feb. 4. / 1880 Dec. 14.	*DOBSON, JAMES MURRAY ..	33 Great George Street, S.W.
	1891 Feb. 3. / 1898 Mar. 15.	DOBSON, SYDNEY THORNTON ..	St. James and Pall Mall El Light Co., Carnaby Street, W.
	1881 Apr. 5. / 1890 Feb. 18.	DODWELL, CHARLES EDWARDS WILLOUGHBY, B.A. (*King's Coll., Nova Scotia*)	46 Coburg Road, Halifax, Scotia.
	1884 Dec. 2.	DOLG, SCROPE BERDMORE ..	Oughterard House, Ought Galway.
	1889 May 7. / 1901 Mar. 26.	DOLBY, ERNEST RICHARD	8 Princes Street, West S.W.
	1894 Dec. 4.	DOMINICO, GUILLERMO FREDERICO JORGE	Inspector General de F Casa de Gobierno, Buenos
t ✠	1882 Feb. 7. / 1891 Apr. 7.	DONALDSON, HAY FREDERICK ..	Wood Lodge, Shooter's Hill,
	1897 Dec. 7.	DORMAN, JOHN WILLIAM, M.A. (*Dubl.*)	Kinsale, Ireland.
	1893 Feb. 7.	DORMAN, RICHARD HENRY ..	County Surveyor, Armagh.
	1887 Apr. 5. / 1903 Dec. 22.	DOUGALL, ANDREW, Jun. ..	Gasworks, Tunbridge Wells.
T t ✠	1882 May 23. / 1887 Dec. 6.	*DOUGLASS, WILLIAM TREGARTHEN	15 Victoria Street, S.W.
W t ✠	1871 Mar. 7. / 1884 May 13.	DOWSON, JOSEPH EMERSON ..	39 Victoria Street, S.W. (G London.)
	1896 Feb. 4.	DREDGE, JAMES, C.M.G... ..	35 Bedford Street, Strand, W.C.
	1854 May 2. / 1864 Nov. 29.	DREW, EDWARD ALEXANDER ..	The Mount, Braughing, Herts.
T t ✠	1881 May 31.	DRUMMOND, DUGALD	L. & S. W. Ry., Nine Elms, S.W.
T t ✠	1875 Feb. 2. / 1878 Apr. 9.	DUCKHAM, FREDERIC ELIOT ..	Millwall Docks, E.
	1904 Apr. 12.	DUGDALE, WILLIAM HENRY ..	Wear Dockyard, Sunderland.
	1882 Feb. 7.	DUNCAN, *Hon.* GEORGE ALEXANDER HALDANE	8 Gloucester St., Boston, Mass.
	1887 Dec. 6.	DUNCAN, GEORGE SMITH ..	P.O. Box 16, Melbourne, Victoria
	1885 Dec. 1.	DUNCAN, ROBERT	Whitefield Works, Govan, Glasg
	1876 Mar. 7.	DUNCANSON, ALEXANDER ..	Municipal Offices, Liverpool.
	1884 May 27. / 1903 Feb. 10.	DUNCANSON, THOMAS	Corporation Waterworks, Liverp
	1883 Dec. 4.	DUNLOP, CHARLES BLACKBURN	The Nizam's State Ry., Secunderabad, Deccan.
	1896 May 5.	DUNN, GEORGE OWEN WILLIAM	Grindlay, Groom & Co., Bombay.
	1879 May / 188	DUNSCOMBE, CLEMENT, .A. (*Dubl.*)	92 Victoria Street, S.W. (Persuade, London.)
	1	QUEMIN, JAMES	Braemar, St. Peter Port, Guerns
S W t ✠		STON, *Sir* ALBERT JOHN, .C.B., R.N.	4 Westcombe Park Road, heath, S.E.
		.OK, WILLIAM	Burgh Surveyor, Aberdeen.
		.KE, THOMAS, B.A. (*Oxon.*) ..	13 Upper Belgrave Road, C Bristol.

Date of Election and of Transfer.	MEMBERS.	
1866 Dec. 4. / 1871 Mar. 28.	EACHUS, GEORGE EEDES	39 Old Queen St., Westminster, S.W (Tottenham 72.)
1893 Apr. 11. / 1901 Dec. 17.	EADY, GEORGE GRIFFIN	53 Victoria Street, S.W.
1896 Feb. 4.	EARLE, HARDMAN ARTHUR ..	Knightsbridge Mansions, Brompton Road, S.W.
1877 Apr. 10. / 1902 Apr. 29.	EATON, EDWARD MICHAEL ..	28 Victoria Street, S.W.
1883 Feb. 6. / 1893 Dec. 19.	EAYRS, JOHN THOMAS	Clarence Chambers, Corporation Street, Birmingham.
1854 Apr. 4.	ECKERSLEY, WILLIAM	37 Palliser Road, West Kensington, W.
1899 Dec. 5.	EDMUNDS, HENRY	2 Queen Anne's Gate, Westminster, S.W.
1904 Jan. 12.	EDWARDS, GUILFORD LINDSAY	B. & N. W. Ry., Gorakhpore, India.
1890 Mar. 4. / 1902 Dec. 16.	*EGERTON, CLAUDE FRANCIS ARTHUR	Blythburgh, Suffolk.
1889 Apr. 2. / 1904 Feb. 16.	EKIN, TOM CHARLES	21 Old Queen Street, Westminster, S.W.
1884 May 27.	ELGAR, FRANCIS, LL.D (*Glas.*), F.R.S. (*Member of Council.*)	18 Cornwall Terrace, Regent's Park, N.W.
1872 Feb. 6. / 1878 Jan. 29.	ELIOT, WHATELY	11 Alfred Street, Plymouth.
1874 Dec. 1. / 1882 May 23.	ELLICE - CLARK, EDWARD BAUDOUIN	Gore Court, Otham, Maidstone.
1882 Dec. 5.	ELLINGTON, EDWARD BAYZAND	9 Bridge Street, Westminster, S.W. (Hydrower, London.)
1897 Dec. 7.	ELLIOTT, *Professor* ARCHIBALD CAMPBELL, D.Sc. (*Edin.*) ..	University College, Cardiff.
1872 Feb. 6.	ELLIOTT, *Cavaliere* JOHN ..	31 Via S. Spirito, Florence.
1880 Mar. 2.	ELLIS, ATTWILL	c.o. Capital & Counties Bank, Dawlish.
1888 Dec. 4. / 1896 Mar. 17.	ELLIS, EDWARD	G. N. Ry., Leeds.
1902 Feb. 4.	ELLIS, HENRY DISNEY	Commissioner of Public Works, Kuching, Sarawak.
1884 Jan. 8.	ELLIS, JOHN DEVONSHIRE ..	Atlas Works, Sheffield.
1887 Dec. 6. / 1896 Mar. 3.	*ELLIS, REGINALD EATON ..	Mewburn, Ellis & Pryor, 70 Chancery Lane, W.C. (Patent, London. Holborn 243.)
1888 May 1. / 1904 Mar. 22.	ELLIS, WILLIAM HENRY ..	Atlas Works, Sheffield.
1866 Apr. 10. / 1884 Mar. 18.	ELLIS, WILLIAM IRLAM	49 Deansgate, Manchester.
1873 May 6. / 1878 Apr. 9.	ELWES, RICHARD GERVASE ..	Suffolk House, Laurence Pountney Hill, E.C.
1873 Dec. 2. / 1893 May 9.	*ELWIN, CHARLES	County Council, Spring Gardens, S.W.
1888 Dec. 4.	ELY, THEODORE NEWEL	Pennsylvania Railroad, Broad St., Philadelphia, Pa., U.S.
1892 Feb. 2. / 1900 Dec. 18.	*EMERSON, AMBROSE	Crown Point, Castle Bar Road, Ealing, W.
1876 May 2. / 1883 Nov. 6.	EMMOTT, PHILIP RICKMAN ..	Willow Brae, Parkstone, Poole.
✠ 1876 Mar. 7. / 1884 Jan. 22.	ENDE, MAX AM	18 Abingdon Street, S.W.
1881 Dec. 6.	ESCOTT, EDWARD RICE SWEET	16 Clifton Road, Halifax.
✠ 1890 May 6. / 1894 Dec. 18.	ESSON, WILLIAM BEEDIE ..	Victoria Works, Old Charlton, S.E.
1874 Dec. 1. / 1895 Nov. 26.	ESTALL, GEORGE	Metropolitan District Ry. Works, West Brompton, S.W.
1896 Mar. 3.	ETLINGER, JOHN ERNEST ..	Ewood, Hampton-on-Thames.
1890 May 6.	EVANS, CHARLES THOMAS ..	The Towers, Lewes Rd., Eastbourne.
1899 Jan. 10.	EVANS, DAVID	Cleveland House, Grangetown, Yorks.
1882 Mar. 7.	EVANS, MORTIMER	Savile Club, Piccadilly, W.
1900 Mar. 6.	EVANS, NEVILLE	Beach Mount, Waterloo, Lancashire.

	Date of Election and of Transfer.	MEMBERS.	
	1890 Dec. 2.	EVANS, WILLIAM	Cyfarthfa Works, Merthyr Tydfil.
	1884 May 27.	EVENS, THOMAS	3 Crescent Road, South Norwood, S.E.
	1870 May 3. 1886 Mar. 1.	*EVERARD, JOHN BREEDON ..	6 Millstone Lane, Leicester.
	1886 Feb. 2. 1903 Feb. 17.	EVERETT, JOHN EDWARD ..	Gyles Quay, Waterford.
✠	1841 Mar. 16. 1865 Dec. 5. 1884 May 6.	EVILL, WILLIAM	43 Gloucester Gardens, W.
t ✠	1882 Jan. 10. 1891 Nov. 3.	EWART, HENRY	Bixley Cottage, Gore Park Road, Eastbourne.
T t F ✠	1891 Mar. 3.	EWING, JAMES ALFRED, M.A. (*Cantab.*), LL.D. (*Edin. and St. And.*), F.R.S.	Director of Naval Education to the Admiralty, Royal Naval College, Greenwich, S.E.
	1874 Dec. 1. 1880 Nov. 9.	EYLES, GEORGE LANCELOT, C.M.G.	12 Dean's Yard, Westminster, S.W. (Gregory, London. Westminster S.W.)
✠	1879 May 27.	FAHEY, CHARLES SWAINE ..	Newstead, Darley Road, Meads, Eastbourne.
	1880 Dec. 7.	FAHIE, WILLIAM JOSEPH ..	49 Ailesbury Road, Dublin.
	1880 Feb. 3. 1897 Nov. 30.	*FAREWELL, CHARLES WILLIAM FREKE	J. R. Farewell, Governor's H... Cardiff.
✠	1887 Dec. 6. 1891 Jan. 27.	FARRAR, SIDNEY HOWARD ..	F. A. Robinson & Co., 54 Old Broad Street, E.C.
	1875 May 4. 1894 Nov. 27.	*FAVELL, THOMAS MILNES ..	Fairwood, Pine Grove, Weybridge.
	1893 May 16. 1904 Mar. 22.	*FAWCETT, EDMUND ALDERSON SANDFORD	Local Government Board, Whitehall, S.W.
m m ✠	1888 May 1. 1896 May 5.	*FAWCUS, WILLIAM PAUL JAMES	14 College Land, St. Mary's Street, Manchester.
	1868 Apr. 7. 1877 Oct. 30.	FENNER, HENRY ALGERNON SHRAPNEL	6 Eliot Hill, Lewisham, S.E.
	1867 Feb. 5.	FENWICK, THOMAS	1 Park Place, Leeds. (Fenwick, Engineer, Leeds.)
	1871 May 2. 1884 Oct. 14.	FERGUSON, HENRY TANNER ..	Wolleigh, Bovey Tracey.
	1892 May 3. 1902 Mar. 18.	*FERGUSON, JOHN	160 Hope Street, Glasgow.
	1880 Dec. 7. 1893 May 16.	FERGUSON, WILLIAM, M.A., B.A.I. (*Dubl.*)	Harbour Board, Wellington, N.Z.
✠	1884 Dec. 2. 1895 Nov. 26.	*FERGUSSON, JOHN COLEMAN ..	75 New Street, Birmingham.
	1886 Jan. 12. 1900 Dec. 18.	FERNAU, JOHN JAMES CONSTANT	59 Osborne Road, Newcastle-on-Tyne.
	1862 Dec. 2. 1869 Feb. 23.	FERNIE, JOHN	Hutchinson, Kansas, U.S.
	[1]900 Feb. 6.	FERRANTI, SEBASTIAN ZIANA DE	Ingleside, Lyndhurst Road, Hampstead, N.W.
	[18]67 May 21. [18]77 Oct. 30.	FERRAR, WILLIAM GREY ..	St. Philip's Vicarage, Bethnal Green, E.
	[19]03 Mar. 3.	FERRIER, ROBERT MUIR, B.Sc. (*Glas.*)	University College, Bristol.
	[18]79 Jan. 14.	FFORDE, JAMES	Raughlan, Lurgan, Ireland.
	[18]81 Mar. 1.	FIDDES, WALTER	2 Queen's Avenue, Tyndall's Park, Clifton, Bristol.
	[18]96 Dec. 1.	FIDDES, WALTER WILLIAM ..	49 Cranbrook Rd., Redland, Bristol.
	[18]9[?] Jan. 10.	FIDLER, HENRY	Admiralty, 47 Victoria Street, S.W.
		FIDLER, *Prof.* THOMAS CLAXTON	University College, Dundee.
		[FI]ELD, GEORGE ROBERT MOYLE	P.W.D., Jhelum, Punjab.
		[FI]ELDING, JOHN	Atlas Works, Gloucester.
		[F]INCHAM, JAMES	Engineer-in-Chief, Hobart, Tasmania.

Date of Election and of Transfer.	MEMBERS.	
1886 Apr. 6. 1896 Mar. 3.	*FIRTH, CHARLES	Ferro Carril del Sud, Buenos Aires.
1875 Dec. 7. 1881 May 31.	FISHER, HENRY OAKDEN ..	Ty Mynydd, Radyr, Cardiff.
1879 Dec. 2. 1884 Nov. 25.	FITCH, BENNETT	7 Grange Road, Ealing, W.
✠ 1883 May 29. 1898 Feb. 15.	*FITZGIBBON, GERALD	Aire and Calder Navigation, Leeds.
✠ 1887 Feb. 1. 1893 Dec. 5.	*FITZMAURICE, MAURICE, C.M.G., M.A., M.A.I. (*Dubl.*)	London County Council, Spring Gardens, S.W
✠ 1879 Feb. 4. 1885 Mar. 3.	FLANNERY, *Sir* JAMES FORTESCUE, M.P.	9 Fenchurch Street, E.C.
1871 May 23.	FLEMING, *Sir* SANDFORD, K.C.M.G.	Ottawa, Canada.
✠ 1875 Feb. 2. 1899 Jan. 17.	*FLETCHER, JAMES RICHARD ..	4 Rectory Terrace, Gosforth-on-Tyne.
1894 Dec. 4. 1904 Feb. 2.	FLETCHER, WALTER JOHN ..	County Surveyor, Wimborne.
1871 Dec. 5. 1885 Nov. 10.	FLOYD, WALTER COMBERMERE LEE	13 Miles Road, Clifton, Bristol.
1890 May 20. 1900 Jan. 30.	FOORD, HERBERT TAYNTON ..	5 Park Road, Winchester.
1880 Dec. 7.	FOOT, GEORGE	Ferro Carril Mexicano, Mexico.
✠ 1867 May 7.	FOOTNER, HARRY	St. David's, Berkhamstead.
1877 May 1.	FORBES, EDMUND BATTEN ...	F. C. Taltal, Taltal, Chile.
1883 May 29. 1889 Mar. 5.	FORBES, *Professor* GEORGE, M.A. (*Cantab.*), F.R.S. ..	34 Great George Street, S.W.
✠ 1889 Apr. 2. 1899 Mar. 28.	FORD, JAMES THOMAS	C.M. Ry., Cartagena, U.S. Colombia.
1895 May 21. 1901 Dec. 17.	FORGIE, JAMES	N.Y. & L.I. Rlrd. Co., 20 West 34th Street, New York, U.S.
✠ 1889 Jan. 8. 1900 Feb. 27.	*FOWLER, ALEXANDER FARQUHARSON	3 Cook Street, Liverpool.
1869 Feb. 2. 1875 Jan. 26.	FOWLER, ALFRED MOUNTAIN ..	1 St. Peter's Square, Manchester.
1873 Feb. 4. 1883 Dec. 11.	*FOWLER, ALPIN GRANT	1 Cambridge Road, Norbiton, S.W
✠ 1871 Feb. 7. 1877 Dec. 18.	FOWLER, GEORGE	Basford Hall, near Nottingham.
1882 Dec. 5. 1888 Nov. 27.	*FOWLER, PERCIVAL	Ellerslie, Kingston Lane, Teddington.
1887 Dec. 6. 1902 Dec. 2.	FOWLER, THOMAS WALKER, M.C.E. (*Melb.*)	Blaris, Carlyle Street, Hawthorn, Melbourne, Victoria.
✠ 1885 Feb. 3. 1900 Feb. 20.	FOWLER, WILLIAM HENRY ..	Manor Avenue, Urmston, Manchester.
1869 Mar. 2. 1880 Nov. 2.	FOX, ARTHUR DOUGLAS	St. George's Lodge, Arlington Villas, Brighton.
1886 Feb. 2. 1900 Jan. 23.	*FOX, CHARLES HEYLAND ..	Broad Street House, Old Broad Street, E.C.
✠ 1866 Feb. 6.	FOX, *Sir* DOUGLAS (*Past-President.*)	28 Victoria Street, S.W. (Traction, London. Westminster 10.)
✠ 1860 Apr. 3.	FOX, DANIEL MAKINSON	9 Orme Court, Bayswater Hill, W.
✠ 1860 May 1.	FOX, FRANCIS	St. Martin's, Torquay.
✠ 1870 Dec. 6. 1874 Mar. 17.	FOX, FRANCIS	28 Victoria Street, S.W. (Traction, London. Westminster 10.)
✠ 1893 Dec. 5. 1902 Mar. 25.	*FOX, FRANCIS DOUGLAS, M.A. (*Cantab.*)	28 Victoria Street, S.W. (Traction, London. Westminster 10.)
1882 Mar. 7. 1891 Mar. 24.	FOX, FREDERICK GEORGE BROOK	Ringmore Vean, Kingsbridge, Devon.
✠ 1877 Dec. 4.	FOX, WILLIAM	5 Victoria Street, S.W.
1877 Jan. 16. 1884 May 27.	*FOXLEE, WILLIAM THEODORE ..	53 Victoria Street, S.W.

	Date of Election and of Transfer.	MEMBERS.	
	1901 Feb. 5.	FRANCIS, GEORGE BLINN ..	Westinghouse, Church, Kerr & C 8 Bridge Street, New York, U.
	1884 Feb. 5. 1901 Dec. 11.	FRANCIS, HARRY	12 Lockyer Street, Plymouth.
✠	1880 Jan. 13. 1883 Apr. 17.	FRANCIS, JOSEPH	New River Office, Clerkenwell, E
	1889 Dec. 3.	FRANKLIN, FREDERICK AUGUSTUS	Buona Vista, Wollongong, N.S.W.
	1902 Dec. 2.	FRASER, HUGH BARRON	Ry. Dept., Gladstone, Queensland
	1873 Dec. 2. 1883 May 22.	FRASER, JAMES	100 Castle Street, Inverness (Fr Civil Engineer, Inverness.)
	1895 May 21. 1897 Apr. 6.	FRASER, JAMES	Engineer-in-Chief for Existing Li Govt. Rys., Bridge Street, Sydn N.S.W.
t ✠	1862 May 6.	FRASER, JAMES GRANT	1 Great Chapel Street, Westminst S.W.
	1875 Feb. 2. 1888 Nov. 20.	FRASER, PHILIP AFFLECK ..	Moniack, Beauly, N.B.
	1894 Jan. 9.	FRASER, SAMUEL GORDON ..	14 Westmoreland Street, Dublin
✠	1882 Dec. 5. 1889 Jan. 15.	FRECHEVILLE, ROBERT JAMES	7 Lothbury, E.C. (Fratribus, Lond. Avenue 2456.)
	1887 Apr. 5.	FREITAS, ANTONIO DE PAULA	Rua Marquez d'Abrantes 82, Rio Janeiro.
	1893 Dec. 5. 1902 Mar. 11.	FRIEND, ASTLEY PASTON ..	Waterworks, Cairo.
✠	1878 May 7. 1892 Jan. 26.	*FRIEND, CHARLES ARTHUR ..	San Vicente 17, Seville, Spain.
	1882 Dec. 5. 1900 Apr. 10.	*FROST, HENRY FRANCIS BURNES	P.W.D., Ferozepore, Punjab.
	1884 May 27.	FROUDE, ROBERT EDMUND, F.R.S.	Admiralty Experiment Works, G port. (Froude, Claremont, Alve stoke.)
✠	1864 Feb. 2. 1878 Jan. 29.	FULLER, GEORGE	71 Lexham Gardens, Kensington, W
	1858 Dec. 7. 1864 Dec. 6.	FULLER, GEORGE LEEDHAM ..	Rosecourt, Theale, Weston-sup Mare.
	1881 Dec. 6. 1888 Nov. 20.	FULTON, JAMES EDWARD ..	27 The Terrace, Wellington, N.Z.
m	1875 May 4. 1884 May 27.	*FYSON, ALFRED	1 Victoria Street, S.W.
	1877 Feb. 6. 1891 Dec. 8.	GABBETT, EDMOND RICH ..	64 Vanbrugh Park, Blackheath, S
	1872 May 7. 1878 May 14.	GAEL, CHARLES EDWARD, B.A. (*Cantab.*)	Charlton Kings, Cheltenham.
	1886 May 18. 1892 Apr. 26.	GAHAN, HENRY HERBERT ..	Agivey House, Culcrow, Ballymo co. Antrim.
	1865 Mar. 7.	GALBRAITH, WILLIAM ROBERT (*Member of Council.*)	20 Victoria Street, S.W. (W minster 252.)
	1884 Feb. 5. 1896 Dec. 15.	GALE, ROBERT MACNISH ..	Water Supply Dept., Ballan, V toria.
	1893 Dec. 5. 1903 Jan. 27.	*GALE, WILLIAM MORRIS	18 Huntly Gardens, Kelvins Glasgow.
	1886 Jan. 12.	GALIZIA, EMMANUEL LEWIS ..	64 Strada Vescovo, Valetta, Mal
	1886 Dec. 7.	GALWEY, WILLIAM, M.A.I. (*Dubl.*)	Waterworks Co., Monte Video.
	1891 Mar. 3.	GAMBLE, FRANCIS CLARKE ..	P.W.D., Victoria, British Colum
	1883 Dec. 4. ..88 Nov. 20.	GANGA RAM, *Rai Bahadur*, C.I.E.	P.W.D., Lahore, India.
	..75 Feb. 2. ..3 Jan. 21.	*GARDINER, JOSEPH JONES ..	Score, Ilfracombe.
	. Mar. 3.	GARFORTH, WILLIAM EDWARD	Snydale Hall, near Pontefract.

	Date of Election and of Transfer.	MEMBERS.	
	1873 Dec. 2. / 1887 Oct. 25.	*GARLAND, WALTER FAITHFULL	c.o. H.B.M. Consul, Batoum, Russia.
	1869 May 11. / 1880 Dec. 21.	GARRETT, FRANK	Leiston Works, Suffolk. (Garrett, Leiston.)
	1872 Jan. 9. / 1878 Feb. 26.	GARWOOD, ALFRED EDWARD ..	Hazlewood, Stow Park, Newport, Mon.
	1895 Jan. 8. / 1904 Feb. 2.	*GASK, PERCY TILLSON	Seaham Harbour, co. Durham.
	1883 Dec. 4. / 1892 Feb. 9.	GASKELL, JAMES STRANACK ..	Surrey Commercial Docks, Rotherhithe, S.E.
	1868 Dec. 1. / 1885 Dec. 15.	GASKELL, THOMAS PENN ..	14 Victoria Street, S.W.
	1875 Mar. 2. / 1881 Nov. 29.	GASKIN, DONALD MACDONALD FORD	22 Lord Street, Liverpool.
	1882 May 2.	GATHERER, ARTHUR BRANDER	Elmwood, Belvedere, Jersey.
	1879 May 6. / 1885 Feb. 24.	GAUNTLETT, DEAN	Hyderabad, Deccan, India.
	1899 Dec. 5.	GAVEY, JOHN, C.B.	Engineer-in-Chief, General Post Office, E.C.
	1904 Apr. 12.	GEDDES, CHARLES DAVID ..	21 Young Street, Edinburgh.
	1891 Dec. 1.	GEE, WILLIAM	c.o. Alfred Kirkland, 90 Carleton Road, Tufnell Park, N.
	1873 Dec. 2.	GEOGHEGAN, HENRY THOMAS	Newport House, Donabate, co. Dublin.
	1876 Mar. 7. / 1879 May 27.	GHEWY, ALBERT BROWN ..	Benwell House, Woodchester, Stroud, Glos.
	1900 Dec. 4.	GIBB, WILLIAM DOIG	Elmfield Road, Gosforth, Newcastle-on-Tyne. (Gas, Newcastle-on-Tyne.)
	1882 Jan. 10.	GIBBONS, THOMAS HUGHES ..	G. W. Ry., Eng.'s Office, Plymouth.
	1904 Jan. 12.	GIBBS, GEORGE	10 Bridge Street, New York, U.S.
	1893 Jan. 10. / 1903 Dec. 22.	*GIBSON, GEORGE LAMBERT ..	G. W. Ry., Harbour Works, Goodwick, Pem.
	1892 Dec. 6.	GILBERT, CHARLES FREDERIC	c.o. H.S. King & Co., Pall Mall, S.W.
	1891 May 5. / 1901 Feb. 12.	*GILBERT, CHARLES HUMPHREY	Inspector-General of Naval Construction, Valparaiso, Chile.
C ✠	1893 Dec. 5. / 1903 Dec. 22.	*GILBERT, WILLIAM	47 Victoria Street, S.W.
	1884 May 6.	GILCHRIST, PERCY CARLYLE, F.R.S.	Frognal Bank, Finchley Rd., N.W.
	1881 Feb. 1. / 1888 May 8.	GILES, GEORGE FREDERICK LEE	Harbour Engineer, Belfast.
	1886 Apr. 6. / 1892 Dec. 6.	GILKES, GILBERT	Lynnside, Kendal.
✠	1884 Jan. 8.	GILLOTT, THOMAS	Butterley Ironworks, Derby. (Butterley, Alfreton.)
	1897 Apr. 6.	GISBORNE, JOHN BYRON	Allestree, Station Road, Loughton.
	1898 Apr. 5 / 1898 Apr. 26.	GLASGOW, ARTHUR GRAHAM ..	38 Victoria Street, S.W.
	1876 Dec. 5. / 1881 Dec. 6.	GLASS, JAMES GEORGE HENRY, C.I.E.	Tamworth, Mitcham, Surrey.
	1884 Dec. 2. / 1900 Mar. 27.	*GLEADOW, FREDERIC	Engineer's Office, G. W. Railway, Paddington, W.
	1896 Mar. 3.	GLEIM, CHARLES OTTO	Dorotheenstrasse 184, Hamburg-Winterhude, Germany.
	1885 Apr. 14. / 1891 Apr. 28.	GLOVER, EDWARD, M.A., B.A.I. (*Dubl.*)	County Surveyor's Office, Naas, co. Kildare.
t ✠	1886 Jan. 12. / 1900 Dec. 19.	GLOVER, JAMES, M.A. (*Cantab.*)	Holly House, Lowton, Lancs.
	1879 May 6. / 1895 Mar. 12.	*GODFREY, WILLIAM BERNARD	23 St. Swithin's Lane, E.C.
t ✠	1879 May 27. / 1883 May 8.	GOLDSMITH, ALFRED JOSEPH ..	Lillington, Moray St., New Farm, Brisbane, Queensland.

	Date of Election and of Transfer.	Members.	
	1873 Feb. 4. 1877 Dec. 11.	GOLDSON, CHARLES BROWNE, M.A. (*Cantab.*)	9 Bath Terrace, Tynemouth.
	1895 Feb. 5.	GOLDWYER, JOHN EDWARD	53 Victoria Street, S.W. (Goldwyer, London.)
	1869 Dec. 7. 1879 Feb. 25.	GOLLA, LUCIEN ALEXANDER	
	1880 Dec. 7. 1904 Apr. 19.	*GOOCH, GEORGE	27 Great George Street, S.W.
	1874 May 12.	GOOCH, WILLIAM FREDERICK	17 Church Road, St. Leonards-on-Sea
	1879 Feb. 4. 1889 Apr. 30.	GOOD, CHARLES	Goldsmith Road, Claremont, Western Australia.
	1888 Dec 4. 1903 Feb. 10.	*GOOD, GEORGE LACY	Govt. Rys., Cape Town, C.C.
	1894 Dec. 4. 1900 Jan. 30.	GOOD, RICHARD HENRY	Summerstown House, Cork.
✠	1886 Feb. 2.	GOOD, WILLIAM	Lisnalee, Ballintemple, Cork.
	1883 Mar. 6.	GOODALL, JOHN	Park Road, Auckland, N.Z.
M m ✠	1887 Dec. 6. 1900 Jan. 23.	*GOODMAN, *Professor* JOHN	Yorkshire College, Leeds.
	1880 Jan. 13. 1893 Dec. 19.	GOODWIN, GEORGE ABRAHAM	28 Victoria Street, S.W.
	1892 Dec. 6.	GOODWIN, GILBERT SMITH	19 James Street, Liverpool. (Wingood, Liverpool.)
	1878 Feb. 5. 1891 Jan. 27.	GOODWIN, SINGLETON, B.A.I. (*Dubl.*)	County Surveyor, Tralee, co. Kerry.
	1884 Feb. 5.	GORDON, ALBERT, M.A.I. (*Dubl.*)	Gt. S. & W. Ry., Inchicore, Dublin.
T t ✠	1867 Dec. 3.	GORDON, GEORGE	Ellerslie, Toorak, Melbourne, Victoria.
	1886 Dec. 7. 1901 Dec. 11.	GORDON, WEBSTER BOYLE, C.I.E.	Govt. Irrigation Engineer, Cape Town, C.C.
	1898 Dec. 6.	GORHAM, JOHN MARSHALL	121 Victoria Street, S.W.
	1863 Apr. 14. 1867 Apr. 30.	GOTT, CHARLES	Bradford, Yorkshire.
	1884 Apr. 1. 1890 Nov. 11.	GOTTO, FRANK	228 Dashwood House, New Broad Street, E.C.
	1882 May 2. 1903 Dec. 22.	GOULD, ROBERT	F. C. del Sud, Buenos Aires.
✠	1866 May 15. 1877 Dec. 11.	GOWER, CHARLES FOOTE	Nova Scotia House, Ipswich.
	1899 Mar. 7.	GRACIE, ALEXANDER	Fairfield Works, Govan, Glasgow.
	1873 Apr. 1. 1882 Jan. 3.	*GRAHAM, CHARLES BENJAMIN	Lyston Hall, Long Melford, Suffolk.
	1891 Dec. 1. 1897 Dec. 21.	GRAHAM, JOHN	G.I.P. Ry., Bombay.
	1874 Mar. 3. 1879 Nov. 25.	*GRAHAM, MALCOLM	29 River Plate House, 13 South Place, E.C.
	1857 Feb. 3.	GRAHAM, ROBERT WILFRID	24 Brunswick Square, Brighton.
	1896 May 19.	GRAHAM, WILLIAM VAUX	5 Queen Anne's Gate, S.W. (Gralator, London. Westminster 656.)
	1902 Jan. 14.	GRANGER, WILLIAM	L. & S. W. Ry., Exeter.
	1875 Dec. 7. 1884 Mar. 25.	*GRANT-DALTON, ALAN	Govt. Rys., Engineer-in-Chief's Office, Cape Town, Cape Colony.
	1881 Feb. 1. 1890 May 20.	*GRANT-DALTON, MALCOLM	Durham Lodge, Brockenhurst, Hants.
	1874 Jan. 13. 1886 Apr. 6.	GRANTHAM, RICHARD FUGE	23 Northumberland Avenue, W.C.
	1886 Jan. 12. 1904 Feb. 2.	GRAY, ANDREW PATON	Govt. Rys., Colombo, Ceylon.
	1878 Dec. 3.	GRAY, GEORGE EDWARD	1115 Bush St., San Francisco, U.S.
	1891 M…	…HENRY ALFRED	D.P.W., Confederation Life Building, Toronto, Canada.
	1890 …	…ROBERT KAYE	106 Cannon Street, E.C.
	188…	…THOMAS	Underhill, Port Talbot, S. Wales.

	Date of Election and of Transfer.	MEMBERS.	
	1891 Dec. 1.	GREEN, JAMES GEORGE	Banco Aleman del Pacifico, Iquique, Chili.
	1876 Mar. 7.	GREENBANK, HENRY . ..	Langho, Wimborne Road, Bournemouth.
	1900 Dec. 4.	GREENHILL, HENRY HUNDSON	Box 172, Bloemfontein, Orange River Colony.
	1887 Mar. 1.	GREENWELL, GEORGE CLEMENTSON	Poynton, Cheshire.
✠	1881 Dec. 6.	GREENWOOD, ARTHUR	Albion Works, Leeds. (Greenwood, Leeds.)
	1904 Mar. 1.	GREENWOOD, HENRY SMITH ..	C. S. A. Railway, Johannesburg, Transvaal.
	1878 May 7. / 1904 Mar. 29.	*GREENWOOD, WILLIAM	Indwe-Maclear Ry., Indwe, Cape Colony.
✠	1881 May 31. / 1896 Dec. 7.	GREENWOOD, WILLIAM HENRY.	Adderley Park Works, Birmingham. (Ammunition, Birmingham. 341.)
	1885 Dec. 1.	GRESHAM, JAMES	Craven Ironworks, Manchester. (Brake, Manchester. 613.)
✠	1876 Dec. 5. / 1902 Dec. 16.	GRIBBLE, THEODORE GRAHAM	459 Salisbury House, London Wall, E.C.
	1893 Jan. 10. / 1895 Feb. 12.	GRIERSON, THOMAS BENJAMIN	15 Victoria Street, Westminster.
	1897 Jan. 12.	*GRIERSON, WILLIAM WYLIE ..	G. W. Ry., Engineer's Office, Paddington, W.
	1896 Apr. 14.	GRIFFIN, EUGENE	44 Broad Street, New York, U.S.
	1894 May 1. / 1900 Jan. 23.	GRIFFIN, THOMAS ROBERT ..	Liscrona, Kilkee, co. Clare.
	1875 Dec. 7. / 1886 Nov. 2.	GRIFFITH, FREDERICK	Waterworks Office, Leicester.
✠	1877 Dec. 4. / 1883 May 29.	GRIFFITH, JOHN PURSER ..	Port and Docks Office, Dublin.
✠	1892 Jan. 12. / 1901 Dec. 11.	GRIFFITH, PERCY	54 Parliament Street, S.W.
	1888 Feb. 7. / 1897 Dec. 7.	GRIFFITHS, THOMAS	Water & Sewerage Dept., Pitt St., Sydney, N.S.W.
	1888 Dec. 4. / 1893 Feb. 28.	GRIMSHAW, JAMES WALTER ..	Miss Grimshaw, 2 Pinewood Road, Branksome Park, Bournemouth.
	1897 Dec. 7.	GRIMSTON, GEORGE SYLVESTER	4 Glenluce Road, Blackheath, S.E.
	1892 Dec. 6.	GRINLING, ARTHUR JAMES ..	32 Friar Gate, Derby.
	1883 Mar. 6.	GROTHE, ALBERT	Apartado 21, Pachuca, Mexico.
	1889 Dec. 3. / 1901 Mar. 26.	*GROVE, FRANK	G. W. Railway, Glenora, Tasmania.
	1875 Mar. 2. / 1883 Jan. 9.	GROVES, HERBERT	13 Langham Mansions, Earl's Court Square, S.W.
✠	1884 Apr. 1.	GRÜNEWALD, JORGE RADEMAKER	Rua de Leste, Rio de Janeiro.
✠	1883 Dec. 4.	GUPPY, THOMAS RICHARD ..	75 Via Gennaro Serra, Naples.
	1892 Dec. 6. / 1903 Feb. 10.	GUTHRIE, JAMES KENNETH ..	Preston Colliery, North Shields.
t ✠	1890 Apr. 1. / 1900 Jan. 30.	GUTTMANN, OSCAR	12 Mark Lane, E.C. (Grantable, London. Avenue 6309.)
	1856 Feb. 5. / 1870 Apr. 26.	GWYNNE, JAMES EGLINTON ANDERSON	Folkington, Polegate, Sussex.
	1870 Mar. 1.	GWYNNE, JOHN	81 Cannon Street, E.C.

	1881 Dec. 6.	HACK, HENRY	Gasworks, Saltley, Birmingham.
	1893 Dec. 5.	HACKETT, EDWARD AUGUSTUS, M.E. (*Royal*)	Greenville, Clonmel, co. Tipperary.
It ✠	1887 Mar. 1. / 1896 Jan. 21.	HADFIELD, ROBERT ABBOTT ..	Parkhead House, Sheffield.
t ✠	1900 Mar. 6.	HAIGH, ARTHUR HARRY, B.Sc. (*Victoria*)	95 Blenheim Crescent, W.

	Date of Election and of Transfer.	MEMBERS.	
	1881 May 3.	HAIRE, ROBERT	Rosetta, South Circular Road, Kilmainham, Dublin.
✠	1879 Feb. 4. / 1891 Dec. 15.	HALES, WILLIAM PRIOR	Ry., Launceston, Tasmania.
	1879 Feb. 4. / 1902 Apr. 29.	HALL, JOSEPH	Executive Engineer, Municipal Offices, Bombay.
✠	1858 Dec. 7. / 1881 Feb. 22.	HALL, WILLIAM	43 Antrim Mansions, Antrim St., Hampstead, N.W.
	1885 Feb. 3. / 1897 Mar. 29.	HALL, WILLIAM SILVER	3 Mitsu Bishi Building, Yayesuch., Tokio, Japan. (Silverhall, Tokio
	1860 Dec. 7.	HALLETT, HOLT SAMUEL	7 Clifton Gardens, Folkestone.
	1886 Dec. 7. / 1890 Feb. 4.	HALLETT, JOHN HARRY	Bute Docks, Cardiff.
	1871 May 2. / 1880 Feb. 27.	HALPIN, DRUITT	17 Victoria Street, S.W. (Halpin, London. Westminster 75.)
	1888 Mar. 6.	HAMILTON, ARCHIBALD	Clyde Navigation, Glasgow.
✠	1877 Jan. 16. / 1880 Dec. 14.	HAMILTON-SMYTHE, ARTHUR JAMES, B.A. (*Dubl.*)	Whitehall Club, S.W.
	1898 Dec. 6.	HAMMOND, ROBERT	64 Victoria Street, S.W.
	1875 Mar. 2. / 1884 Jan. 2.	HAMMOND, WALTER JOHN	The Grange, Knockholt, Sevenoaks.
	1885 Dec. 1.	HANN, EDMUND MILLS	Aberaman, Aberdare.
	1887 May 3. / 1897 Mar. 29.	*HANNA, SAMUEL	Carrick, Esher, Surrey.
✠	1877 May 29. / 1885 Feb. 3.	HANSON, CHARLES RASTRICK	Kwala Lumpur, Selangor, S.S.
	1887 May 24. / 1891 Jan. 13.	HARDING, JOHN REGINALD	Engineer-in-Chief, Chinese Imperial Customs, Shanghai.
t m ✠	1872 Mar. 5. / 1877 Apr. 17.	*HARDING, JOSIAH	Casilla 836, Valparaiso, Chile.
	1903 Feb. 3.	HARDING, WILLIAM JOSHUA	42 Kempshott Road, Streatham Common, S.W.
	1903 Jan. 13.	*HARDISTY, JOHN	Bridge House, Chesterfield.
✠	1863 Apr. 14. / 1879 Feb. 4.	HARGRAVE, CHARLES TOWNSHEND	Inspector General of Roads, Adelaide, South Australia.
	1885 Dec. 1.	HARGRAVE, HENRY JAMES BENNET, M.A. (*Dubl.*)	16 Shrewsbury Road, Merrion, co. Dublin.
	1884 Dec. 2. / 1896 Jan. 28.	*HARGRAVE, HENRY WILLIAM	Moir's Chambers, St. George's Terrace, Perth, Western Australia.
	1886 Apr. 6. / 1904 Mar. 29.	*HARGRAVE, JOSHUA HARRISON, B.A. (*Queen's*)	G.N. Ry., Amiens Street, Dublin.
	1890 Dec. 2.	*HARINGTON, HERBERT SEPTIMUS	United Service Club, Simla.
	1898 Dec. 6.	HARMAN, EDWARD ALFRED	Gas Department, Huddersfield.
	1881 May 31. / 1888 Nov. 27.	HARPUR, WILLIAM	197 Severn Road, Cardiff.
	1881 Apr. 5.	HARRINGTON, TIMOTHY	73 Highbury New Park, N.
✠	1890 May 6. / 1901 Apr. 2.	HARRIOTT, GEORGE MOSS, C.I.E.	Nagpur, C.P., India.
	1874 Dec. 1. / 1882 Feb. 28.	HARRIS, EDMUND LEGH	Odessa, Russia.
	1848 Mar. 7. / 1858 Jan. 26.	HARRIS, GEORGE WILLIAM	Millicent, South Australia.
	1877 Dec. 4. / 1886 Nov. 16.	HARRIS, HENRY GRAHAM	5 Great George Street, S.W. (Welbram, London. Westminster 6
	1874 Apr. 14. / 187[illegible]	HARRIS, RICHARD READER, K.C.	51 Clapham Common North, S.W.
✠	[illegible]	HARRISON, CHARLES AUGUSTUS	N.E. Ry., Newcastle-on-Tyne.
	[illegible]	HARRISON, GEORGE DAY	Staffs. Potteries Waterworks, Hanley.
	[illegible]	HARRISON, JOHN ERNEST	160 Hope Street, Glasgow.
	[illegible]	HARRISON, JOHN FREDERICK	45 John Street, Glasgow.

	Date of Election and of Transfer.	MEMBERS.	
✠	1900 Feb. 6.	HARRISON, JOSEPH HUTCHINSON	2 Exchange Place, Middlesbrough.
	1870 May 3.	HART, JOHN HENRY EUSTACE	H. S. King & Co., 65 Cornhill, E.C.
L m ✠	1856 Dec. 2. 1862 Apr. 1.	HARTLEY, *Sir* CHARLES, K.C.M.G., F.R.S.E. ..	26 Pall Mall, S.W.
	1874 Dec. 1. 1882 Apr. 18.	HARVEY, WILLIAM	
	1904 Feb. 2.	HASBROUCK, CHARLES ALFRED	1315 Monadnock Block, Chicago, U.S.
	1866 Mar. 6.	HASSARD, RICHARD	1 Victoria Street, S.W.
	1884 Feb. 5. 1902 Feb. 11.	*HASSELL, LLOYD	Ry. Dept., Brisbane, Queensland.
✠	1885 May 5.	HASWELL, CHARLES HAYNES ..	324 West 78th Street, New York, U.S.
	1895 Dec. 3. 1901 Feb. 5.	HATCH, FREDERICK HENRY, Ph.D. (*Bonn*)	Box 1030, Johannesburg, Transvaal.
	1899 Dec. 5. 1903 Dec. 22.	HATCH, WILLIAM THOMAS ..	Metropolitan Asylums Board, Embankment, E.C.
	1902 Dec. 2.	HAWDON, WILLIAM	Linthorpe, Middlesbrough.
✠	1879 May 6. 1889 Nov. 15.	HAWGOOD, HARRY	Bradbury Building, Los Angeles, Calif., U.S.
	1892 Apr. 5.	HAWKS, JAMES DUDLEY	Mackinac Ry., Detroit, Mich., U.S.
n ✠	1867 Feb. 5. 1874 Mar. 10.	HAWKSHAW, JOHN CLARKE, M.A. (*Cantab.*) (*Past-President. Member of Council.*)	33 Great George Street, S.W.
✠	1867 May 21.	HAWKSLEY, CHARLES (*Past-President.*)	30 Great George Street, S.W.
	1897 Apr. 6. 1903 Jan. 13.	HAWKSLEY, KENNETH PHIPSON	30 Great George Street, S.W.
t ✠	1892 May 3. 1895 Jan. 8.	HAY, DAVID	2 Queen Square Place, Westminster, S.W.
	1896 Feb. 4.	HAY, GEORGE	12 Mount Avenue, Ealing, W.
	1891 Dec. 1.	HAY, PETER SETON, M.A. (*New Zealand*)	P.W.D., Wellington, N.Z.
✠	1881 Mar. 1. 1885 Feb. 24.	HAY, ROBERT	Dunedin, N.Z.
	1883 Apr. 3. 1892 Nov. 8.	HAYES, EDWARD	Stony Stratford.
	1898 Dec. 6. 1904 Feb. 23.	*HAYWARD, THOMAS	G.I.P. Ry., Engineer's Office, Bombay.
t ✠	1894 Mar. 6. 1901 Dec. 11.	*HEAD, ARCHIBALD POTTER ..	47 Victoria Street, S.W. (Westminster 237.)
	1894 Dec. 4. 1903 Dec. 22.	HEAP, RAY DOUGLAS THEODORE	Royal Arsenal, Woolwich.
t ✠	1884 Dec. 2.	HEARSON, THOMAS ALFRED, R.N.	22 Southampton Buildings, Chancery Lane, W.C.
	1890 Feb. 4.	HEBBERT, FREDERICK BENBOW	Office of Consulting Engineer for Railways, 105 Clive St., Calcutta.
	1892 May 24. 1898 Nov. 29.	HECTOR, MAXIMILIAN	Friedberger Landstrasse 38, Frankfurt-am-Main.
m ✠	1864 Jan. 12. 1868 Dec. 18.	HEDERSTEDT, HENRY BURDETT	Twyford Lodge, Southlands Rd., Bickley.
m ✠	1876 Mar. 7. 1884 Dec. 23.	*HEDGES, KILLINGWORTH ..	1 Emery Hill Street, Westminster, S.W. (Soojee, London.)
	1901 Apr. 2.	HEDRICK, IRA GRANT	2216 East 8th Street, Kansas City, Missouri, U.S.
	1879 Dec. 2. 1886 Feb. 16.	HEENAN, GEORGE FREDERIC HAMMERSLEY	21 Clarinda Park East, Kingstown, co. Dublin.
C ✠	1872 Feb. 6. 1876 Mar. 21.	HEENAN, HAMMERSLEY	4 Chapel Walks, Manchester.
✠	1884 Feb. 5.	HEENAN, ROBERT HENRY HAMMERSLEY	Harbour Works, Cape Town, C.C
M ✠	1880 Dec. 7. 1887 Apr. 5.	*HELE-SHAW, *Professor* HENRY SELBY, LL.D. (*St. Andrews*), F.R.S.	University, Liverpool.

	Date of Election and of Transfer.	MEMBERS.	
	1885 May 19. 1896 Dec. 22.	*HELLINS, HENRY HERBERT ..	Engineer's Office, City Hall, Dubl
	1889 Dec. 3. 1900 Mar. 27.	HELPS, JAMES WILLIAM	Gasworks, Croydon.
	1878 Apr. 2.	*HEMANS, ARTHUR WILLOUGHBY	H. S. King & Co., Pall Mall, S.W
	1894 Dec. 4. 1899 Dec. 12.	HENDERSON, BRODIE HALDANE	14 South Place, Finsbury, E.C.
m ✠	1866 Mar. 6. 1874 Nov. 24.	HENDERSON, DAVID MARR ..	Victory House, King's Ro Hove.
	1880 Dec. 7. 1884 Nov. 4.	HENDERSON, JOHN BAILLIE ..	Brisbane, Queensland.
	1893 Dec. 5. 1903 Apr. 7.	HENDERSON, ROBERT	14 Queen Street, Edinburgh.
	1869 Jan. 12. 1882 Mar. 21.	HENNELL, THOMAS	Parliament Mansions, Victoria Stre S.W.
	1869 Dec. 7. 1879 Feb. 4.	HENSLOWE, FRANCIS BOYLE ..	Lynden, Branksome Wood Ro Bournemouth.
✠	1889 May 7. 1899 Mar. 28.	HENZELL, CHARLES GEORGE ..	Catcleugh, Otterburn, Northumb land.
	1877 Mar. 6. 1889 Nov. 26.	HEPWORTH, JOSEPH	Buccleuch Street Works, Edinbur
	1883 May 29. 1886 Nov. 16.	HERING, RUDOLPH	170 Broadway, New York, U.S.
	1875 May 4. 1893 Jan. 10.	HERRING, JOHN WILLIAM ..	River Wear Commission, Sund land.
	1901 Apr. 23.	HERRING, WALTER RALPH ..	Granton House, Edinburgh.
	1890 Dec. 2.	HERSCHEL, CLEMENS	2 Wall Street, New York, U.S.
✠	1880 May 4. 1891 May 5.	*HERVEY, MATTHEW WILSON	East Bilney Hall, East Dereha Norfolk.
	1880 May 4. 1893 Nov. 14.	*HESKETH, EVERARD	Dartford Ironworks, Kent.
	1885 May 19. 1896 Nov. 16.	HESLOP, THOMAS HIND BLUMER	County Surveyor, Norwich.
	1886 Dec. 7.	HETHERINGTON, JOHN MUIR ..	19 Upper Grosvenor Street, W.
	1876 Dec. 5. 1881 Jan. 11.	HEWSON, THOMAS	City Engineer, Leeds.
	1883 May 1. 1892 Nov. 8.	HEYLAND, HERBERT KYFFIN	Loughrigg, Cavendish Road, Sutt Surrey.
	1874 Feb. 3. 1876 Feb. 8.	HICKSON, ROBERT ROWAN PURDON	President, Harbour Trust Co mission, Sydney, N.S.W.
	1887 May 24. 1902 Dec. 2.	HIDE, WILLIAM SEYMOUR ..	Amos & Smith, Albert Dock, Hul
	1890 Apr. 1.	HIGGINS, ANDREW FRANK ..	Prospect House, Darjeeling, Beng
✠	1888 Dec. 4. 1895 Jan. 22.	HIGGINS, GEORGE	60 Market Street, Melbourn Victoria.
	1882 May 23.	HIGHAM, *Sir* THOMAS, K.C.I.E.	1 Codrington Place, Clifton Pa Bristol.
	1901 Mar. 5.	HIGSON, CHARLES HUGH	106 Eccles Old Road, Pendlet Manchester.
	1878 Dec. 3.	HIGSON, JACOB	18 Booth Street, Manchester.
	1878 Dec. 3.	HIGSON, JOHN	(Mining, Manchester. 1034.)
✠	1887 Feb. 1. 1891 Nov. 3.	HILL, ARTHUR EDMUND BRETON, B.A.Sc. (*McGill*) ..	New Westminster, British Colu bia.
✠	1891 Dec. 1. 1894 Jan. 16.	HILL, ERNEST PRESCOT	3 Victoria Street, S.W.
T t ✠	1872 Feb. 6.	HILL, GEORGE HENRY (*Member of Council.*) ..	3 Victoria Street, S.W. (Thirl London.)
	1897 Feb. 2. 1903 Mar. 31.	HILL, HARRY PRESCOT	Albert Chambers, Albert Squ Manchester.
	1887 Dec. 6. 1896 Feb. 4.	HILL, HENRY ASHTON	South Staffs. Waterworks, Birm ham.
	1875 Dec. 7. 1890 Apr. 22.	HILL, HENRY ELLIS	9 Victoria Street, S.W.

Date of Election and of Transfer.	MEMBERS.	
1877 Dec. 4.	HILL, JAMES NINIAN	41 Chaucer Road, Acton, W.
✠ 1883 May 29. 1901 Feb. 12.	HILL, LUKE MULLOCK, B.E. (*Queen's*)	Municipal Engineer, Georgetown, Demerara.
1896 Dec. 1. 1901 Feb. 19.	HILLER, EDWARD GEORGE ..	Oakholme, Wilbraham Road, Alexandra Park, Manchester.
1871 Mar. 10. 1883 Nov. 13.	HILTON, JOHN EDWARD	The Chestnuts, Lambourn, Berks.
1889 Jan. 8. 1896 Jan. 21.	*HINNELL, HENRY LEONARD ..	26 Corporation Street, Manchester.
1893 May 16. 1904 Jan. 26.	HOARE, ARTHUR	8 Elphinstone Circle, Bombay.
1879 Feb. 4. 1895 Feb. 26.	HOARE, EDWARD ARTHUR ..	Lake St. John Ry., Quebec, Canada.
✠ 1883 May 1. 1885 Dec. 15.	HOBSON, GEORGE ANDREW ..	28 Victoria Street, S.W. (Traction, London. Westminster 10.)
1886 May 4.	HOBSON, JOSEPH	Grand Trunk Ry., Montreal, Canada.
✠ 1891 May 5. 1899 Nov. 28.	*HODGE, HENRY WILSON	1 Nassau Street, New York, U.S.
1881 Dec. 6. 1891 Nov. 5.	*HODGES, ROBERT NATHANIEL	c.o. Macnaughton & Co., 79 Mark Lane, E.C.
1885 Feb. 3. 1893 Nov. 7.	HODGSON, HARRISON	9 New Broad Street, E.C.
1878 Feb. 5. 1886 Mar. 23.	*HODGSON, WILLIAM	Eng.'s Office, Midland Ry., Derby.
1879 Feb. 4. 1891 Nov. 5.	*HODSON, CHARLES WILLIAM ..	Grindlay, Groom & Co., Bombay.
1870 Mar. 1. 1886 Apr. 13.	HODSON, GEORGE	Abbey Buildings, Princes St., Westminster, S.W. (Output, London.)
1881 Dec. 6. 1891 Feb. 17.	HOGAN, JOHN POICTEVIN LEMON	Grindlay, Groom & Co., Bombay.
1886 Apr. 6.	HOGG, ALEXANDER LAUDER ..	43 Carlyle Road, Edgbaston.
1878 Feb. 5.	HOGG, CHARLES PULLAR ..	53 Bothwell Street, Glasgow. (Crouch, Glasgow.)
1902 Jan. 14.	HÖK, CHRISTOPHER WILHELM	10 Karlaplan, Stockholm.
1903 Apr. 7.	HOLBROOK, ELLIOT	La Jolla, San Diego, California, U.S.
1882 Feb. 7. 1887 May 24.	HOLDEN, JAMES	G. E. Ry., Stratford, E. (Eastden, London.)
✠ 1893 May 2. 1898 Nov. 29.	HOLGATE, THOMAS	5 Victoria Street, S.W.
1861 Apr. 9. 1879 Jan. 7.	HOLLINGSWORTH, CHARLES ERNEST	5 Ritherdon Road, Upper Tooting, S.W.
1880 Feb. 3. 1896 Feb. 25.	*HOLME, CHARLES HENRY ..	Rathburne, Duns, N.B.
1880 Mar. 2. 1888 Mar. 6.	HOLMES, ARTHUR BROMLEY ..	36 Princes Avenue, Liverpool.
1884 Jan. 8. 1897 Mar. 2.	*HOLMES, JOHN HENRY	Wellburn, Jesmond, Newcastle-on-Tyne.
1887 Feb. 1. 1897 Jan. 19.	HOLMES, ROBERT WEST	P.W.D., Wellington, N.Z.
✠ 1875 Feb. 2.	HOLT, ALFRED	1 India Buildings, Liverpool. (Alfred Holt, Liverpool.)
1895 Jan. 8. 1901 Feb. 26.	*HOLT, FOLLETT	Entre Rios Ry., Parana, Argentina.
✠ 1875 Apr. 6. 1879 Jan. 7.	HOLTHAM, EDMUND GREGORY	5 Round Hill Crescent, Brighton.
✠ 1895 Jan. 8.	HOMFRAY, SAMUEL GEORGE ..	8 Great George Street, S.W.
1864 May 24. 1876 Apr. 25.	HOOD, WELLS	Ravenswood, Surrey Road, Bournemouth West.
1890 Feb. 4. 1903 Dec. 22.	*HOOPER, HERBERT ROSS, M.A. (*Oxon.*)	34 Vanbrugh Park, Blackheath, S.E.
1892 Apr. 5. 1900 Feb. 20.	HOPKINS, WALTER BERNARD ..	Clun House, Surrey Street, W.C.

	Date of Election and of Transfer.	MEMBERS.	
t ✠	1882 Dec. 5. / 1888 Jan. 24.	HOPKINSON, CHARLES, B.Sc. (*Victoria*)	29 Princess Street, Manchester.
T t 8 ✠	1885 Jan. 13. / 1890 Nov. 11.	HOPKINSON, EDWARD, M.A. (*Cantab.*), D.Sc. (*Lond.*)	Ferns, Alderley Edge, Cheshire.
	1880 Jan. 13. / 1880 Feb. 25.	HORAN, JOHN, M.E. (*Royal*) ..	82 George Street, Limerick. (Ro Limerick. 142.)
	1889 Apr. 2. / 1897 Apr. 6.	HORNBURY, GEORGE FRANCIS ..	Byculla Ironworks, Bombay.
	1878 May 28. / 1883 Jan. 30.	HORSLEY, CHARLES	22 Wharf Road, City Road, N.
	1899 Mar. 7.	HORWOOD, JOHN HOWELL ..	The Laurels, Romilly Road, Ba Cardiff.
	1883 Jan. 9. / 1897 Nov. 30.	*HOUGHTON, THOMAS HARRY ..	63 Pitt Street, Sydney, N.S.W.
	1886 Apr. 6. / 1894 Apr. 17.	HOUSON, DAVID	P.W.D., Trial Bay, Macleay Ri N.S.W.
✠	1881 Apr. 5. / 1900 Jan. 30.	HOUSTON, JAMES LENNOX ..	151 Cannon Street, E.C.
	1882 Apr. 5.	HOWDEN, JAMES	195 Scotland Street, Glasgow. (H den, Glasgow. 1467.)
✠	1867 Feb. 5. / 1872 Dec. 3.	HOWKINS, JOHN	Queensberry Lodge, Grenton R Edinburgh.
	1888 May 1.	HOWSON, RICHARD	2 Exchange Place, Middlesbrou
	1891 Dec. 1. / 1904 Feb. 16.	HOY, HENRY ALBERT	Springfield, Bromley Cross, Bolt
	1897 Jan. 12.	HOYLE, JAMES ROSSITER	Norfolk Works, Sheffield.
	1884 Feb. 5. / 1898 Mar. 22.	HUDLESTON, FERDINAND ..	25 Victoria Street, S.W. (W minster 423.)
	1880 May 4. / 1888 Jan. 17.	HUDSON, FRANK	Central Uruguay Railway, Mo Video.
	1879 Feb. 4. / 1887 Jan. 25.	HUDSON, JOHN GEORGE	Glenholme, Bromley Cross, Bolt
	1881 Dec. 6.	HUGHES, ARTHUR JOHN, C.I.E.	
	1904 Jan. 12.	HUGHES, GEORGE	Regent House, Lostock Park, Bol
	1879 May 6. / 1896 Dec. 22.	HUGHES, JOHN ELLIS	Reservoir Works, Marsden, York
	1881 May 31.	HUGHES, JOHN SYLVESTER ..	Festiniog Ry., Portmadoc.
	1885 Jan. 13.	HUGHES, WALTER CHARLETON, C.I.E.	Chairman, Port Trust, Bombay.
	1879 Feb. 4. / 1888 Oct. 30.	HUGHES, WILLIAM, M.E. (*Queen's*)	3 Hengist Road, Bournemouth.
	1885 May 5. / 1897 Feb. 2.	*HUMBY, ALBERT JAMES	Government Railways, Maritzb Natal.
	1881 May 31. / 1891 Dec. 8.	HUMBY, HENRY GEORGE ..	39 Victoria Street, S.W.
	1895 May 21.	HUMFRESS, GEORGE	N. W. Ry., Lahore, India.
T t ✠	1884 Dec. 4. / 1903 Apr. 7.	*HUMPHREY, HERBERT ALFRED	38 Victoria Street, S.W.
	1895 Mar. 5.	HUMPHREYS, ALEXANDER CROMBIE	31 Nassau Street, New York, U (Humglas, New York.)
	1899 Mar. 7.	*HUMPHREYS, GEORGE WILLIAM	40 Cheyne Court, Chelsea, S.W.
	1888 Apr. 10.	HUMPHREYS, ROBERT HARRY ..	Deptford Pier, S.E.
✠	1881 Mar. 1.	HUNT, CHARLES	15 Victoria Street, Westmins S.W.
	1901 Mar. 5.	HUNT, ROBERT WOOLSTON ..	The Rookery, Chicago, U.S.
✠	1880 Feb. 4. / 1889 Nov. 28.	HUNTER, SIDNEY HERBERT ..	202 Bow Road, E. (Venator, Lond Stratford 45.)
	1904 Apr. 12.	HUNTER, THOMAS CHARLES ..	Admiralty, 21 Northumberl Avenue, W.C.
	1865 May 2. / 1878 May 14.	HUNTER, WALTER	17 Victoria Street, S.W.

	Date of Election and of Transfer.	MEMBERS.	
✠	1891 May 5.	HUNTER, WILLIAM HENRY ..	Ship Canal, Eng.'s Office, Manchester.
	1868 May 19. 1897 Nov. 30.	HURST, WILLIAM	L. & N. W. Ry., Brinklow, Coventry.
m ✠	1879 May 27. 1886 Mar. 16.	*HURTZIG, ARTHUR CAMERON ..	2 Queen Square Place, S.W. (Westminster 33.)
	1867 Feb. 5. 1873 Dec. 23.	HUTCHINS, GEORGE ALBERT ..	Clive House, Welshpool, North Wales.
	1897 Jan. 12.	HUTCHINSON, CHRISTOPHER CLARKE	13 The Boltons, S. Kensington, S.W. (Kensington 980.)
	1888 Feb. 7. 1903 Dec. 22.	HUTCHINSON, SYDNEY HUTTON COOPER	United Service Club, Calcutta.
	1886 Jan. 12. 1891 Nov. 9.	HUTCHINSON, WILLIAM, M.C.E. (*Melbourne*)	Ry. Construction Dept., Sydney, N.S.W.
	1892 Dec. 6. 1903 Feb. 24.	HUTCHISON, DANIEL LEAN, M.Sc. (*Victoria*)	G.N. & City Ry., Poole Street, New North Road, N.
	1862 Mar. 4.	HUTTON, DARNTON, M.A. (*Dubl.*)	14 Cumberland Terrace, Regent's Park, N.W.
	1902 Feb. 4.	IMPETT, JOHN JAMES	1 Calle Manco Capac, Callao, Peru.
	1897 Apr. 6.	INGHAM, WILLIAM PORRITT ..	Royal Exchange, Middlesbrough.
m ✠	1876 Dec. 5. 1884 Mar. 18.	*INGLIS, JAMES CHARLES (*Member of Council.*)	G. W. Ry., Paddington, W.
	1871 Jan. 10. 1877 Nov. 27.	INGLIS, JOHN WILLIAM, F.R.S.E.	c.o. National Bank of New Zealand Paeroa, Auckland, N.Z.
	1875 Feb. 2. 1879 Apr. 29.	IRWIN, HENRY, C.I.E.	Ran View, Ootacamund, Madras.
	1882 Jan. 10. 1900 Apr. 10.	*ISHIGURO, ISOJI	Admiralty, Tokio, Japan.
	1891 Dec. 1.	IVATT, HENRY ALFRED	G. N. Ry., Doncaster.
	1900 Dec. 4.	IVENS, JOHN HENRY ANDERSON	P.W.D., Meerut, N.W.P., India.
	1876 May 2. 1881 Apr. 5.	IZAT, ALEXANDER, C.I.E. ..	Springfield, Dollar, N.B.
	1874 Apr. 14. 1879 Dec. 23.	JACKSON, EDWARD	Port Engineer, Karachi, India.
	1882 Apr. 4.	JACKSON, SAMUEL, C.I.E. ..	23 Calverley Park, Tunbridge Wells.
	1881 Mar. 1.	JACOB, AUGUSTUS HAMILTON, M.A., M.A.I. (*Dubl.*)	Glenelg, Westbourne Park Road, Bournemouth.
	1902 Dec. 2.	JACOB, FRANCIS	Ellesdene, Westcombe Park, S.E.
	1891 Dec. 1.	JACOB, LIONEL MONTAGUE ..	P.W.D., Rangoon, Burma.
	1885 Dec. 1.	JACOBS, CHARLES MATTATHIAS	128 Broadway, New York, U.S.
✠	1884 Dec. 2. 1891 Jan. 27.	*JACOMB-HOOD, JOHN WYKEHAM	L. & S. W. Ry., Waterloo, S.E.
	1890 Apr. 1.	JAFFREY, WILLIAM	3 Victoria St., S.W. (Kahort, London.)
	1887 Dec. 6. 1899 Jan. 24.	JAMES, CHARLES CARKEET ..	Municipality, Bombay.
	1879 May 6. 1887 Nov. 22.	JAMES, HENRY ALEXANDER ..	38 Leigham Vale, Streatham, S.W.
✠	1868 Dec. 1.	JAMES, JOHN WILLIAM	Dr. P. M. Wood, Ashfield, N.S.W.
	1894 Dec. 4.	JAMESON, ARTHUR SAMPSON ..	Netherleigh, South Nutfield, Surrey.
t ✠	1878 Jan. 15. 1887 Feb. 8.	JAMIESON, *Professor* ANDREW, F.R.S.E.	16 Rosslyn Terrace, Kelvinside, Glasgow.
	1888 Dec. 4. 1893 Mar. 7.	JAQUES, WILLIAM HENRY, *Captain* U.S.N. *ret.*	483 Beacon Street, Boston, Mass., U.S.

	Date of Election and of Transfer.	MEMBERS.	
	1882 Mar. 7. 1884 Oct. 14.	JARDINE, ALEXANDER WILLIAM	G. V. Hellicar, Solicitor, Brisb Queensland.
	1872 Feb. 6.	JEBB, GEORGE ROBERT (*Member of Council.*)	Fairyfield, Great Barr, Birmingh
	1893 Dec. 5. 1900 Jan. 30.	JELLETT, HENRY HOLMES, B.A.I. (*Dubl.*)	Seoni, Chappara, Central Provin India.
TS t ✠	1892 Dec. 6. 1901 Feb. 19.	JENKIN, BERNARD MAXWELL..	17 Victoria Street, S.W. (Kinema London. Westminster 621.)
	1860 Apr. 3.	JENKIN, SILVANUS WILLIAM ..	Liskeard, Cornwall.
	1895 Dec. 3.	JENNINGS, JAMES HENNEN ..	1 London Wall Buildings, E.C.
	1884 Mar. 4. 1891 May 12.	JENNINGS, WILLIAM TINDAL ..	Molson's Bank Building, Toro Canada.
	1898 Dec. 5.	JERVIS, JAMES THOMAS	28 Victoria Street, S.W.
✠	1885 Dec. 1. 1894 Mar. 6.	JOBSON, CHRISTOPHER	Weld Club, Perth, Western A tralia.
	1893 Dec. 5. 1904 Apr. 19.	JOHNS, JOHN HENRY	Box 231, Johannesburg, Transva
✠	1881 Mar. 1. 1894 Oct. 16.	*JOHNSON, FRANCIS ROBERT ..	21 Langside St., Winnipeg, Cana
	1887 Dec. 6. 1899 Feb. 28.	*JOHNSON, HENRY ARTHUR ..	15 The Exchange, Bradford.
	1862 May 20.	JOHNSON, RICHARD	58 Coolhurst Road, Crouch End,
✠	1867 Dec. 3.	JOHNSON, SAMUEL WAITE ..	Lenton House, The Park, Notti ham.
	1898 Feb. 1.	JOHNSON, TOM RICHARD ..	G. N. Ry., Engineer's Dept., Kin Cross, N.
	1885 Mar. 3.	JOHNSON, WALTER CLAUDE ..	32 Hyde Park Gardens, W. (Jo dab, London. Paddington 15
	1883 Feb. 6. 1886 May 18.	JOHNSTON, ANDREW	5 Westminster Palace Garde Victoria Street, S.W.
	1900 Dec. 4.	JOHNSTON, HENRY JOSEPH, C.I.E.	P.W.D., Jhelum Canal, Rasul, Punj
	1888 Apr. 10. 1898 Nov. 29.	*JOHNSTON, JAMES	Waterworks, Bond Street, Bright
✠	1867 Mar. 5.	JOHNSTON, ROBERT EDWARD ..	Joint Railways Office, Birkenhea
	1870 Mar. 1. 1877 Nov. 27.	JOLL, HENRY	4 Osborne Place, Plymouth.
	1878 Feb. 5. 1893 May 16.	JONES, ARTHUR DANIEL ..	3 Border Crescent, Sydenham, S.
	1875 Feb. 2. 1891 Nov. 3.	JONES, CHARLES	The Lodge, Culmington Ro Ealing, W.
TWSt ✠	1869 May 27. 1875 Apr. 11.	JONES, HARRY EDWARD ..	142 Palace Chambers, Bridge Stre Westminster, S.W.
	1891 Dec. 1. 1902 Mar. 4.	*JONES, HARRY HERBERT	Hessle, Lytton Grove, Putney Hi S.W.
	1876 Feb. 1. 1897 Dec. 7.	JONES, ISAAC MATTHEWS ..	City Surveyor, Chester.
✠	1875 Feb. 2. 1881 Nov. 15.	JONES, JOHN ALFRED, F.R.S.E.	Parry & Co., 70 Gracechurch Stre E.C.
	1886 Dec. 7.	JONES, PEYTON	The Hermitage, Mona Place, Sou Yarra, Melbourne, Victoria.
	1886 Jan. 12. 1893 Nov. 7.	JONES, ROBERT EDWARD ..	P.W.D., Sydney, N.S.W.
	1899 Dec. 5.	JONES, THOMAS	1 Prince's St., Westminster, S.W.
	1886 Dec. 7. 1903 Dec. 22.	*JONES, WILLIAM HEMMING ..	Dockyard, Liverpool.
	1892 Dec. 6.	JOYCE, ALFRED	18 Reighton Road, Clapton, N.
✠	1885 Dec. 1. 1892 Jan. 26.	JOYCE, FREDERICK TALBOT ..	29 Waterloo Place, Dublin.
	1887 Dec. 6.	JOYNER, ROBERT BATSON, C.I.E.	Lake View, Pittville, Cheltenham.
	1891 Mar. 3.	JUDSON, WILLIAM PIERSON ..	Deputy State Engineer of Ne York, Albany, N.Y., U.S.

	Date of Election and of Transfer.	MEMBERS.	
T t ✠	1885 Jan. 13. 1891 Jan. 13.	KAPP, GISBERT	Ulmenallee 26, Westend, Berlin.
✠	1873 Dec. 2. 1878 Dec. 3.	KEATING, EDWARD HENRY ..	Toronto Ry., Toronto, Ont., Canada.
	1884 Jan. 8. 1887 Oct. 25.	KEATING, HENRY, M.A. (*Dubl.*)	Tralee, Ireland.
	1885 Dec. 1.	KEEFER, GEORGE ALEXANDER	D.P.W., New Westminster, British Columbia.
	1877 Dec. 4.	KEEFER, THOMAS COLTRIN, C.M.G. (*Member of Council.*)	D.P.W., Ottawa, Canada.
✠	1883 Dec. 4. 1888 Dec. 18.	KEELE, THOMAS WILLIAM ..	Harbours & Rivers Branch, P.W.D., Sydney, N.S.W.
✠	1873 May 20.	KEELING, GEORGE WILLIAM ..	10 Lansdown Terrace, Cheltenham.
	1883 May 1. 1894 Feb. 20.	*KEENE, PERCY EDWARD	Midland Ry., Bhilsa, India.
	1902 Jan. 14.	KELLEY, HOWARD GEORGE ..	1,124 Guaranty Building, Minneapolis, Minn., U.S.A.
✠	1890 Dec. 2.	KELLY, WILLIAM REDFERN ..	Dalriada, Malone Park, Belfast.
	1878 Jan. 15. 1904 Feb. 16.	*KEMPE, HARRY ROBERT	Engineer-in-Chief's Office, General Post Office, E.C.
T t F ✠	1879 May 27.	KENNEDY, ALEXANDER BLACKIE WILLIAM, LL.D. (*Glas.*), F.R.S. (*Vice-President.*)	17 Victoria Street, S.W. (Kinematic, London. Westminster 621.)
	1875 Dec. 7.	KENNEDY, JOHN	Montreal, Canada.
t ✠	1880 Dec. 7. 1884 May 13.	KENNEDY, NEIL	Norfolk House, Laurence Pountney Hill, E.C.
✠	1892 Apr. 5. 1896 Nov. 24.	KENSINGTON, FREDERICK ..	2 Copthall Buildings, E.C.
	1890 Dec. 2. 1902 Dec. 16.	*KER, HUGH TORRANCE	Harbour Works, Folkestone.
✠	1895 Feb. 5.	KERNOT, MAURICE EDWIN ..	Ry. Dept., Melbourne, Victoria.
	1901 Feb. 5.	KERNOT, *Professor* WILLIAM CHARLES, M.A., M.C.E. (*Melb.*)	University, Melbourne, Victoria.
	1889 Dec. 3. 1902 Dec. 2.	KIDD, HECTOR	Colonial Sugar Refining Co., Sydney, N.S.W.
m ✠	1887 May 24. 1900 Mar. 6.	*KIDD, WILLIAM	c.o. Punchard & Co., 151 Cannon Street, E.C.
	1871 May 2. 1877 Nov. 27.	KIERZKOWSKI-STEUART, CHARLES FERDINAND DE	7 Collingham Road, Cromwell Road, S.W.
	1863 Dec. 1. 1877 Nov. 27.	KILGOUR, GEORGE	Box 813, Cape Town, C.C.
	1859 Dec. 6. 1875 Nov. 9.	KIMBER, JAMES	18 Lymington Rd., West End Lane, West Hampstead, N.W.
	1870 Apr. 5. 1879 Mar. 25.	KINCAID, JOSEPH, M.A. (*Dubl.*)	29 Great George Street, S.W. (Kincaid, London. Westminster 11.)
t ✠	1878 Feb. 5. 1889 Dec. 10.	KINDER, CLAUDE WILLIAM, C.M.G.	c.o. H.B.M. Consul, Tientsin, China.
	1889 Apr. 2.	KING, MAURICE	
	1874 May 5.	KING, WILLIAM	Gas Office, Duke Street, Liverpool.
	1873 Mar. 4. 1889 Nov. 15.	*KING, WILLIAM HENRY	St. Heliers, Sydney Road, Walton-on-Thames.
	1886 Jan. 12. 1902 Mar. 11.	KINGSTON, WILLIAM, B.E. (*Queen's*)	R.E. Office, Tidworth, Andover.
	1883 May 29.	KINSEY, WILLIAM BARNS ..	Dundee, North Shepstone, Natal.
	1892 Mar. 1.	KIRBY, CHARLES ANTHONY ..	G. N. Ry., Boston.
	1875 May 4.	KIRBY, FREDERICK HALL ..	19 Devonshire Terrace, Lancaster Gate, W.
	1903 Apr. 7.	KIRKBY, SAMUEL ALEXANDER, M.A. (*Cantab.*)	Carrigmore, Queenstown.
T t ✠	1865 May 23.	KIRKHAM, THOMAS NESHAM ..	C. R. Wade-Gerey, St. Neots, Hunts.
	1892 Mar. 1. 1896 May 12.	KIRKLAND, THOMAS	17 Victoria Street, S.W. (Westminster 5255.)

	Date of Election and of Transfer.	Members.	
	1875 Mar. 2.	Kirtley, William	31 Larkhall Rise, Clapham, S.W.
	1888 Mar. 6. 1901 Dec. 11.	*Kitchingman, Dawson ..	Waterworks, Cray, Brecon.
	1903 Jan. 13.	Kite, Frederick William ..	Friedensthal, Gloucester Ro Kingston Hill.
	1876 Dec. 5.	Kitson, *Sir* James, *Bart.*, M.P.	Monk Bridge Ironworks, Leeds. (7
	1866 Mar. 6. 1877 June 26.	Knowles, George	Billiter Square Buildings, E.C.
✠	1879 Dec. 2.	Kraft, John	Société Cockerill, Seraing, Belgiu
	1894 Feb. 6.	Kramer, Arnold	Parliament Mansions, Victo Street, S.W.
✠	1880 Apr. 6.	Kühl, Charles Henry Leopold, C.M.G.	European Commission of t Danube, Sulina.
	1898 Dec. 6. 1903 Feb. 24.	Kussmaul, Christian	Board of Works, 501 Collins Stre Melbourne, Victoria.
t ✠	1873 May 6. 1876 Apr. 25.	Kyle, John	New Harbour Works, Dover.
	1887 Mar. 1. 1894 Nov. 6.	*Kyle, John, Jun.	Harbour Works, Colombo, Ceylon

	1893 Dec. 5. 1899 Apr. 18.	Lacey, Ernest Matthew ..	2 Queen Anne's Gate, S.W.
	1885 May 19. 1897 Feb. 16.	Lacey, Frederick William ..	Borough Engineer, Bournemouth
	1885 Dec. 1. 1900 Apr. 3.	Laffan, George Bastable, B.E. (*Queen's*)	Borough Engineer, Maritzbu Natal.
	1894 Mar. 6.	Laing, Andrew	Wallsend Slipway, Wallsend-on-Ty
	1893 Dec. 5. 1903 Dec. 22.	Laing-Meason, Gilbert ..	South Canterbury Club, Tima New Zealand.
	1886 Mar. 2. 1902 Apr. 22.	*Lake, Harry Herbert ..	P.W.D., Gwalior, Central India.
	1885 Dec. 1. 1895 Oct. 22.	Lane, Alexander Maurice	Belize, British Honduras.
	1876 May 30. 1883 Nov. 3.	Langdon, William	Tower Hill, Looe, Cornwall.
	1881 May 31. 1885 Nov. 24.	Lapage, Richard Herbert ..	Sheen House, Walmer. (Lapa Walmer.)
	1874 Feb. 3. 1885 Nov. 10.	*Large, Philip Townshend Somerville	Carnaeway Rectory, Kilcullen, Kildare.
	1878 Mar. 5. 1894 May 22.	Larminie, John Charles ..	Rahan, Bray, co. Wicklow.
	1877 May 1. 1882 Apr. 4.	Latham, Albert	Town Hall, Margate.
	1865 May 2. 1868 May 19.	Latham, Baldwin	Parliament Mansions, Victo Street, S.W.
T t ✠	1859 Dec. 6. 1866 Dec. 17.	Latham, John Herbert, M.A. (*Cantab.*)	Ngaruawahia, Auckland, N.Z.
	1902 Feb. 4.	La Touche, James Norman Digues	Berhampur, Moorshedabad, Beng
	1884 May 6.	Laurence, William Knox ..	G.W. Ry., Bristol.
	1888 Apr. 10. 1899 Feb. 21.	*Law, Herbert Henry	21 Pembroke Road, Kensington,
	1878 May 7. 1880 Feb. 24.	Lawder, Arthur William ..	17 Farquhar Road, Upper Norwo S.E.
	1880 Dec. 7. 1884 Dec. 16.	Lawder, James Ormsby ..	Lawderdale, Ballinamore, Leitrim.
O ✠	1886 Jan. 12. 1899 Jan. 10.	Lawford, George Maxwell	9 Bridge Street, Westminster, S.

	Date of Election and of Transfer.	MEMBERS.	
t ✠	1870 Mar. 1. 1877 May 29.	LAWS, WILLIAM GEORGE ..	40 Grey Street, Newcastle-on-Tyne.
	1901 Feb. 5.	LAWSON, ALLAN JOHN	4 Adelphi Terrace, W.C.
	1868 Mar. 3.	LAYBOURNE, RICHARD	The Firs, Malpas, Newport, Mon.
	1893 May 2.	LEA, HENRY	38 Bennett's Hill, Birmingham.
	1885 Feb. 3. 1892 Feb. 16.	LEAN, JOEL	Priddock House, Bamford, Sheffield.
	1886 Dec. 7.	LEAVITT, ERASMUS DARWIN ..	Cambridgeport, Mass., U.S.
	1879 Feb. 4. 1885 Feb. 3.	LEE, JOSEPH JOHN	L. & N. W. Ry., Engineer's Office, 126 Higher Ardwick, Manchester.
✠	1888 Feb. 7. 1903 Apr. 21.	*LEES, ARTHUR EDWIN TREVILLION	F. A. Robinson & Co., 54 Old Broad Street, E.C.
m	1886 Dec. 7. 1896 Nov. 24.	*LEGG, WILLIAM ANDREW ..	Thomas Stewart, 6 St. George's Chambers, Cape Town, C.C.
	1872 Dec. 3. 1879 May 27.	LEGGATT, WILLIAM BENJAMIN	27 Ladbroke Grove, W.
	1879 Feb. 4. 1889 Feb. 5.	LEIGH, ROBERT KENNAWAY ..	Hong Kong.
	1898 Dec. 6.	LEITCH, DONALD CALDER ..	Municipal Engineer, Johannesburg, Transvaal.
✠	1883 Jan. 9.	LE MESURIER, WILLIAM HENRY	36 Slatey Road, Birkenhead.
	1865 May 23. 1877 Jan. 30.	LEMON, JAMES	Lansdowne House, Southampton.
	1896 Apr. 14.	LE QUESNE, WILLIAM HENRY	c.o. Grindlay & Co., Parliament St., S.W.
	1904 Jan. 12.	LE ROSSIGNOL, ALFRED ERNEST	8 Victoria Square, Newcastle-upon-Tyne.
T t W S ✠	1872 Jan. 9.	LESLIE, *Sir* BRADFORD, K.C.I.E.	8 Sussex Place, Regent's Park, N.W.
	1891 Dec. 1. 1898 Feb. 15.	LESLIE, BRADFORD	7 The Sanctuary, Westminster, S.W.
	1890 Dec. 2.	LESLIE, MORICE	c.o. Grindlay & Co., Parliament Street, S.W.
	1891 Mar. 3. 1901 Dec. 11.	LESLIE, ROBERT FLETCHER ..	East Indian Ry., Allahabad, India.
	1885 Feb. 3.	LEWIS, GEORGE	Imperial Chambers, Albert Street, Derby.
	1891 Jan. 13. 1900 Dec. 18.	*LEWIS, SIDNEY COOKE	Mansergh & Sons, 5 Victoria Street, S.W.
	1879 May 6. 1895 Jan. 22.	*LEWIS, WILLIAM CUTHBERT	Millwood House, Wrotham Heath, Sevenoaks.
	1865 Mar. 7. 1869 Jan. 19.	LEWIS, *Sir* WILLIAM THOMAS, *Bart.*	The Mardy, Aberdare.
✠	1892 Dec. 6. 1898 Mar. 15.	*LIDDLE, WILLIAM	Hodbarrow Sea Wall, Millom, Cumberland.
	1885 Dec. 1. 1902 Mar. 4.	*LIGHT, ERNEST EDWARD ..	Ry. Dept., Perth, Western Australia.
m ✠	1881 Dec. 6.	LIGHTFOOT, THOMAS BELL ..	35 Queen Victoria Street, E.C. (Separator, London.)
	1890 Feb. 4.	LINDENTHAL, GUSTAV	45 Cedar Street, New York, U.S.
	1891 Mar. 3.	LINDLEY, JOSEPH	Aleja Ujazdowska 17, Warsaw.
	1881 Feb. 1.	LINDLEY, ROBERT SEARLES ..	Godstone Place, Godstone, Surrey.
	1878 May 28.	LINDLEY, WILLIAM HEERLEIN	Frankfurt-am-Main.
	1880 Dec. 7. 1887 Feb. 22.	LINDSAY, CHARLES COXHEAD ..	180 Hope Street, Glasgow. (Civileng, Glasgow.)
	1897 Dec. 7.	LINEHAM, WILFRID JAMES ..	21 Newstead Road, Lee, S.E.
	1882 Apr. 4.	LISBÔA, JOAQUIM MIGUEL RIBEIRO	Post Box 195, Rio de Janeiro.
	1871 Mar. 7. 1880 Apr. 13.	LIST, GEORGE HENRY	Birmingham Corporation Waterworks, Ludlow.
✠	1878 Feb. 5. 1887 Feb. 1.	*LIST, JOHN, *Royal Naval Reserve*	3 St. John's Park, Blackheath, S.E.
✠	1887 Dec. 6. 1897 Nov. 30.	LITSTER, DAVID MICHAEL ..	c.o. Grindlay & Co., Parliament St., S.W.

	Date of Election and of Transfer.	MEMBERS.	
	1872 Mar. 5.	Livesey, *Sir* George Thomas	Shagbrook, Reigate.
	[illegible] May [illegible] [illegible] Jan. [illegible]	*Livesey, Harry	14 South Place, Finsbury, E.C.
	[illegible] Dec. [illegible] [illegible] Feb. 19	Livesey, James	14 South Place, Finsbury, E.C.
	[illegible] Feb. 4.	Lloyd, Robert Samuel ..	Hayward-Tyler & Co., 90 W[illegible] cross St., E.C.
Y t ✠	1884 Mar. 7.	Lloyd, William	19 Finchley Road, N.W.
	[illegible] Apr. 7.	L[illegible], Samuel Joshua	Engineer, Municipality, Madras
	[illegible] Jan. [illegible] 1896 May [illegible]	Lobley, Joseph	Boro' Surveyor, Hanley, Staffs.
✠	[illegible] Jan. [illegible] [illegible] Apr. [illegible]	Lobnitz, Frederic	Clarence House, Renfrew.
	[illegible] Jan. [illegible] [illegible] Apr. [illegible]	*Lockhart, William Strokach	67 Granville Park, Blackheath, [illegible]
	[illegible] Apr. [illegible] [illegible] Feb. [illegible]	Lockyer, Norman Joseph ..	N.E. Ry., Loco. Works, Gatesh[illegible] on-Tyne.
	[illegible] Dec. 5.	Longbotham, Jonathan ..	Sharrow House, Sheffield.
	1887 May 24.	Longden, John Alfred ..	Stanton-by-Dale, Nottingham. (L[illegible] den, Stanton, Alfreton.)
	1[illegible] Dec. 4. 1[illegible] F[illegible] 11.	Longfield, Richard William Frederick, B.A.I. (*Dubl.*)	County Surveyor, Bandon, co. C[illegible]
	1874 Mar. 3. [illegible] May 11.	Longridge, Michael, M.A. (*Cantab.*)	Linkvretten, Ashley Road, [illegible] Causeway, Cheshire.
t ✠	[illegible] May 2[illegible] 1[illegible] Nov. 5.	Lopes, George, B.A. (*Cantab.*)	1 Queensberry Place, S.W.
	1[illegible] Jan. [illegible] 1[illegible] Dec. 1[illegible]	*Lovegrove, Edwin James ..	Hornsey District Council, So[illegible] wood Lane, N.
	1[illegible] Feb. 7. 1[illegible] Apr. 2[illegible]	*Low, Percy Archibald ..	Bridport House, Rugby.
Y t m ✠	1885 Mar. 3. 1[illegible] Mar. 2[illegible]	*Lowcock, Sidney Richard ..	50 Queen Anne's Gate, Westmins[illegible] S.W.
	1867 Mar. 5. 1866 Feb. 4.	Lowe, Charles Harlowe ..	30 Somerset St., Portman Square,
✠	1877 Dec. 4.	Lowe, John Henry	23 Alderbrook Road, Balham, S.
	1885 Dec. 1.	Lowe, John Landor, B.Sc. (*Lond.*)	Midland Ry., Derby.
	1891 Jan. 13.	Lowe, Louis John McKenzie	Casilla 655, Buenos Aires.
	1884 Feb. 5. 1895 Mar. 5.	Lucas, William Owen	Deasland, Oxshott, Surrey.
	1901 Feb. 5.	Luiggi, Luigi	22 Esmeralda, Buenos Aires.
	1880 Dec. 7.	Luke, Arthur George	Woodlands, Broadstone, Wimbor[illegible]
	1904 Apr. 19.	Luke, William Joseph ..	John Brown and Co., Clydebank, N[illegible]
	1885 Mar. 3.	Lumsden, Hugh David	63 Homewood Avenue, Toro[illegible] Canada.
	1876 Mar. 7.	Lundie, Cornelius	Rhymney Railway, Cardiff.
	1876 Feb. 1. 1879 Mar. 4.	Lundie, George Archibald	Cardiff.
	1893 Jan. 10. 1902 Apr. 15.	Lunn, William	Drainage Works, Bridgwater.
	1878 May 7.	Lupton, *Professor* Arnold ..	6 De Grey Road, Leeds. (Arn[illegible] Lupton, Leeds. 330.)
	1892 May 3. 1900 Feb. 13.	*Lyell, David	Box 5228, Johannesburg, Transv[illegible]
	1887 Jan. 11. 1900 Dec. 19.	*Lyell, Robert, B.Sc. (*Edin.*)	Monte Caseros, Argentina.
	1881 Dec. 6.	Lynch, Francis Joseph ..	Ottawa, Canada.
	1877 Dec. 4. 1882 May 23.	Lynde, Francis Gascoigne ..	Fairseat, Sevenoaks.
	1875 May 11. 1877 Nov. 27.	Lynde, James Henry	Buckland, Ashton-on-Mersey, M[illegible] chester.

Date of Election and of Transfer.	MEMBERS.	
1884 Dec. 2. / 1890 May 20.	LYNN, GRAHAM RIGBY	Chief Engineer's Office, Baroda, Bombay.
✠ 1882 Dec. 5.	LYSTER, ANTHONY GEORGE. ..	Dockyard, Liverpool.
m ✠ 1882 Feb. 7. / 1891 Sept. 29.	*MACALISTER, DANIEL	Water Trust, Municipal Buildings, Greenock, N.B.
✠ 1881 May 31. / 1896 May 12.	MACALISTER, ROBERT	c.o. H. S. King & Co., Pall Mall, S.W.
1879 Feb. 4. / 1886 Feb. 9.	MACASSEY, LUKE LIVINGSTON	38 Parliament Street, S.W.
1889 Dec. 3. / 1900 Dec. 18.	*MACAULAY, FREDERIC WILLIAM	Birmingham Water Dept., Springfield House, Ludlow. (Water, Ludlow.)
1881 Jan. 11. / 1902 Dec. 2.	MACBRAIR, ROBERT ALEXANDER	City Engineer, Lincoln.
1873 May 6. / 1879 Nov. 4.	MACBRIDE, ROBERT KNOX, C.M.G.	Junior Carlton Club, Pall Mall, S.W.
1894 Dec. 4. / 1902 Jan. 28.	MACCABE, WILLIAM BERNARD	City Engineer, Calcutta.
1864 Apr. 5. / 1867 Dec. 10.	McCLEAN, FRANK, M.A. (*Cantab.*), F.R.S. ..	Norfolk House, Norfolk Street, Strand, W.C.
1902 Mar. 4.	*McCLURE, HUGH HANNAY ..	John Aird & Co., Avonmouth Docks, Bristol.
1891 May 5.	McCORMICK, JOHN MACNEILL	Govt. Rys., Hobart, Tasmania.
1882 Feb. 7. / 1886 Nov. 2.	McCUDDEN, EDMUND GERALD JAMES	c.o. H. S. King & Co., 65, Cornhill, E.C.
1889 Mar. 5. / 1896 May 12.	McCULLOUGH, FREDERICK WILLIAM	Waterworks Engineer, Belfast.
1891 Apr. 7.	McDONALD, ALEXANDER BEITH	City Engineer, Glasgow.
1874 Mar. 3.	McDONALD, ARTHUR HARMAN	1 Osborne Road, Clifton, Bristol.
1892 May 24. / 1899 Mar. 28.	*McDONALD, GEORGE CHAMPION	Cambrian Rys., Oswestry.
1881 Dec. 6. / 1888 Feb. 28.	*McDONALD, JOHN ALEXANDER	c.o. McDonald, Scales & Co., 4 Chapel Street, Cripplegate, E.C.
1878 Mar. 5.	McDONALD, JOHN ALLEN .. (*Member of Council.*)	Eng.'s Office, Midland Ry., Derby. (McDonald, Derby.)
t ✠ 1872 Feb. 6.	McDONNELL, ALEXANDER, M.A. (*Dubl.*)	Rydens, Hersham Road, Walton-on-Thames.
1894 May 1. / 1904 Mar. 29.	*McDONNELL, IAN ALISTER, B.A.I. (*Dubl.*)	East Indian Ry., Dinapore, Bengal.
1875 Feb. 2. / 1881 Mar. 15.	McDOUGALL, NIEL	Guildhall Chambers, Lloyd Street, Manchester.
1879 Dec. 2. / 1900 Dec. 18.	*MACFARLANE, DONALD	H.M. Naval Yard, Simon's Town, Cape Colony.
1879 Apr. 1.	McGREGOR, JOSIAH	c.o. Mrs. McGregor, 37 Harold Road, Upper Norwood, S.E.
1869 Dec. 1.	McHUTCHIN, WILLIAM	United Service Club, Bangalore, India.
1867 Dec. 3.	MACINTYRE, JOHN STEVENSON	14 Victoria Street, S.W.
1903 Jan. 13.	MACKAIL, GEORGE HENDERSON	c.o. H. Oxley, 2 Oakfield Road, Clapton, N.E.
1890 Feb. 4. / 1897 Nov. 30.	MACKENZIE, ARCHIBALD THOMAS	c.o. A. Fletcher & Co., 2 St. Helen's Place, E.C.
T t ✠ 1875 May 4. / 1878 Apr. 30.	MACKENZIE, JOHN BOWER ..	St. Edmunds, Glen Huntly, Melbourne, Victoria.
1904 Jan. 12.	MACKENZIE, NICOL FINLAYSON	Royal Indian Engineering College, Staines.
1866 Jan. 9. / 1871 Dec. 5.	McKERROW, ALEXANDER ..	17 Victoria Street, S.W. (Westminster 505.)
1859 Mar. 1. / 1885 Dec. 1.	McKIE, HUGH UNSWORTH ..	White House, Spondon, Derby.
1882 Dec. 5. / 1899 Dec. 12.	McKIE, ISAAC SHEPHERD ..	Hazeldene, Park Rd., Sittingbourne.

	Date of Election and of Transfer.	MEMBERS.	
	1885 Dec. 1. 1899 Feb. 7.	McKie, James	White House, Spondon, Derby.
	1880 Jan. 13. 1885 Feb. 24.	McKinney, Hugh Giffen ..	The Exchange, Sydney, N.S.W
	1870 May 24. 1893 Nov. 7.	Mackinnon, Matthie Charles	Hatton, Torquay.
	1859 May 24. 1878 Apr. 30.	McLandsborough, William ..	Selsley Lawn, Cheltenham.
	1888 Dec. 4. 1898 Mar. 22.	*Maclaren, James Waddell Boyd	Chartered Bank Buildings, Si pore, S.S.
✠	1876 May 2. 1892 Nov. 8.	McLaren, John	Midland Engine Works, Hun Leeds. (McLaren, Leeds.)
	1879 May 6. 1887 May 17.	McLaughlin, Frederick James	8 Old Park Avenue, Balham, S.
	1894 Apr. 3.	Maclay, William Walter, M.A. (*New York*)	Box 512, Glens Falls, New Y U.S.A.
	1889 Dec. 3. 1903 Dec. 22.	Maclean, Charles William	Ports and Harbours Dept., l bourne, Victoria.
	1883 Dec. 4. 1897 Mar. 15.	*MacLean, Francis William	Railway Dept., Dunedin, N.Z.
	1893 May 2. 1903 Mar. 10.	McLellan, Dugald	Caledonian Ry., Buchanan St Station, Glasgow.
	1878 May 28.	MacLeod, Henry Augustine FitzGerald	340 Cooper Street, Ottawa, Cana
	1894 Feb. 6. 1903 Dec. 22.	*McMahon, Peter Valentine	195 Clapham Road, S.W.
	1884 Dec. 2. 1891 May 5.	MacPherson, Duncan	Canadian Pacific Ry., Montreal.
	1870 Dec. 6. 1878 Feb. 19.	Madeley, James Chatburn ..	Highworth, Ashford, Kent.
✠	1899 Dec. 5.	Maginnis, Arthur John ..	28 Chapel Street, Liverpool.
	1889 Feb. 5. 1898 Dec. 20.	Mair, Hugh	Vestry Hall, Hammersmith, W.
W t ✠	1873 May 20.	Mair-Rumley, John George	The Hammonds, Udimore, Susse
	1879 Dec. 2.	Mais, Henry Coathupe ..	Prell's Buildings, Melbourne, Victo
	1886 Dec. 7.	Malcolm, Bowman	Northern Counties Ry., Belfast.
	1882 Mar. 7. 1901 Dec. 11.	*Malet, Alan Arthur Grenville	Local Government Board, Wh hall, S.W.
✠	1863 May 5. 1876 Dec. 5.	Mallet, Robert Trefusis ..	66 Cornwall Gardens, S.W.
	1889 Dec. 3.	Maltby, Thomas Crichton ..	C. J. Deck, Trafalgar St., Nelson, I
	1882 Dec. 5.	Mammatt, John Edward ..	1 Albion Place, Leeds.
	1883 Dec. 4.	Mance, *Sir* Henry Christopher, C.I.E.	32 Earl's Court Square, S.W.
	1870 May 24. 1893 Jan. 17.	Manisty, Edward	39 Chalk Farm Road, N.W.
t ✠	1888 Mar. 6.	Mann, Isaac John	5 St. Augustine's Road, Bedford
	1876 May 2. 1897 Feb. 23.	Mannering, Horace John ..	30 Garlies Road, Forest Hill, S.
	1870 May 24. 1887 Nov. 8.	Manners, Charles Robert ..	12 Lombard Street, Inverness.
	1864 Dec. 6.	Manning, John Richards ..	110 London Road, Forest Hill,
	1887 May 3.	Manoug, Joseph Latif, *Bey*	Cairo.
	1891 May 5. 1900 Mar. 27.	*Mansergh, Ernest Lawson ..	5 Victoria Street, S.W.
T t ✠	1859 Apr. 5. 1873 Dec. 9.	MANSERGH, James, F.R.S. (*Past-President. Member of Council.*)	5 Victoria Street, S.W. (Su London.)
	1891 Dec. 1. 1899 Apr. 11.	*Manton, Arthur Woodroffe, B.Sc. (*Birmingham*)	G.W. Ry., Old Sodbury, Glos.
✠	1881 Dec. 6. 1892 Nov. 29.	Marchant, Frederic William	Box 74, Timaru, New Zealand.

Date of Election and of Transfer.	MEMBERS.	
✠ 1889 May 21. / 1901 Jan. 15.	MARCHBANKS, JAMES	Wellington and Manawatu Ry., Wellington, N.Z.
1892 Dec. 6.	MARLEY, JOHN WILLIAM ..	Thornfield, Darlington.
m 1883 Mar. 6. / 1891 Nov. 17.	*MARRIOTT, WILLIAM	M. & G. N. Rys., Melton Constable. (Marriott, Melton Constable.)
1897 Dec 7.	MARSH, CHARLES WILLIAM EARLE	Rockdale, Stow Park, Newport, Mon.
1877 May 29. / 1890 Mar. 4.	*MARSH, HENRY, C.I.E.	Irrigation Dept., P.W.D., Agra, N.W.P., India.
1862 Mar. 4.	MARSH, THOMAS EDWARD MILLES	34 Grosvenor Place, Bath.
1891 Feb. 3.	MARSH, WILLIAM SUTCLIFFE ..	The Elms, Mount Pleasant, Swansea.
1904 Feb. 2.	MARSHALL, FRANK THEODORE	St. Peter's Works, Newcastle-on-Tyne.
✠ 1877 Feb. 6. / 1887 Apr. 19.	MARSHALL, WILLIAM BAYLEY	Richmond Hill, Birmingham. (Augustus, Birmingham. 3533.)
St ✠ 1845 June 3. / 1866 Apr. 10.	MARSHALL, WILLIAM PRIME ..	Richmond Hill, Birmingham. (Augustus, Birmingham. 3533.)
1857 Jan. 13. / 1877 May 8.	MARTEN, EDWARD BINDON ..	Pedmore, near Stourbridge.
✠ 1883 May 1. / 1893 May 2.	MARTEN, EDWARD DIMMACK, M.A. (*Cantab.*)	Lamberhurst, Bath Road, Cheltenham.
1891 May 5. / 1904 Mar. 29	*MARTEN, HUBERT BINDON ..	L.B. & S.C. Ry., 332 Queen's Road, Battersea, S.W.
1883 Feb. 6.	MARTIN, DANIEL FRANCIS ..	Thornbank, Kenley, Surrey.
1881 Apr. 5.	MARTIN, EDWARD PRITCHARD	The Hill, Abergavenny.
✠ 1897 Jan. 12.	MARTIN, EDWIN LEWIS	Roden Lodge, Beauchamp Roothing Ongar.
✠ 1888 Dec. 4.	MARTIN, HENRY WILLIAM ..	Sherwood, Newport Road, Cardiff.
1859 Apr. 5.	MARTINEAU, WILLIAM	Brazilian St. Ry. Co., 405 Mansion House Chambers, Queen Victoria Street, E.C.
1884 Dec. 2. / 1901 Dec. 17.	*MARWOOD, HORACE RICHARD ..	Govt. Rys., Port of Spain, Trinidad
1896 May 19.	MASCHWITZ, CARLOS	Laprida 352, Buenos Aires.
1884 Apr. 1.	MASON, CLAYTON TURNER ..	Fremantle, W. Australia.
1888 May 15.	MASSEY, WILLIAM HENRY ..	25 Queen Anne's Gate, S.W. (Massive, London.)
1886 Feb. 2.	MATHER, *Sir* WILLIAM, M.P...	Salford Ironworks, Manchester.
1887 Feb. 1. / 1895 Dec. 3.	MATHESON, DONALD ALEXANDER	Caledonian Ry., Buchanan Street Station, Glasgow.
t ✠ 1876 May 2.	MATHESON, EWING	13 Walbrook, E.C. (Matheson, Walbrook.)
1865 Mar. 7.	MATHEWS, HENRY MONTAGU, C.I.E.	Clayton, Surbiton Hill Park.
1877 Feb. 6. / 1884 May 6.	MATTHEWS, THOMAS	Trinity House, E.C.
1870 Dec. 6. / 1876 Dec. 5.	MATTHEWS, WILLIAM, C.M.G. (*Member of Council.*)	9 Victoria Street, S.W. (Penlee, London. Westminster 47.)
t ✠ 1882 Apr. 4. / 1889 Apr. 30.	MATTHEWS WILLIAM	Waterworks Engineer, Southampton.
1871 May 2. / 1877 Dec. 18.	MAUDSLAY, WALTER HENRY ..	69 Cadogan Gardens, S.W.
1895 Jan. 8. / 1899 Nov. 28.	MAVOR, HENRY ALEXANDER ..	3 Windsor Circus, Kelvinside, Glasgow.
F ✠ 1896 Feb. 4.	MAW, WILLIAM HENRY	35 Bedford Street, Strand, W.C.
1885 Dec. 1. / 1898 Feb. 8.	MAWBEY, ENOCH GEORGE ..	Boro' Surveyor, Leicester.
1904 Jan. 12.	*MAWSON, ERNEST OSCAR ..	P.W.D., Bombay.
mm ✠ 1873 Jan. 14. / 1883 May 29.	*MAXWELL, JOSEPH PRIME ..	Wellington, N.Z.
1885 Mar. 3. / 1902 Dec. 16.	*MAY, CHARLES RAMSDEN ..	Orwell Lodge, Erith, Kent.
1886 Dec. 7. / 1894 Mar. 6.	MAY, FRANCIS JOHN CHARLES	25 Compton Avenue, Brighton.

	Date of Election and of Transfer.	MEMBERS.	
	1893 Dec. 5. 1902 Dec. 16.	MAY, WALTER	Nine Elms Ironworks, Reading.
✠	1876 May 2. 1879 Feb. 4.	MAYLOR, WILLIAM	Hanley Grange, Hanley Cas Worcestershire.
✠	1894 Dec. 4. 1902 Mar. 25.	*MAYNE, CHARLES	Municipal Council, Shanghai.
	1879 Feb. 4. 1891 Mar. 30.	MEADE, THOMAS DE COURCY ..	Town Hall, Manchester.
S t ✠	1887 Dec. 6. 1890 Dec. 9.	MEADE-KING, WILLIAM OLIVER EVELYN	Local Govt. Board, Whitehall, S.
	1863 May 5.	MEDEIROS, VIRIATO DE	Rio de Janeiro.
✠	1888 Feb. 7.	MEIK, CHARLES SCOTT	16 Victoria Street, S.W. (Snowd London.)
t ✠	1876 May 2. 1880 Apr. 27.	*MEIK, PATRICK WALTER ..	
	1886 May 4. 1897 Dec. 7.	MELDRUM, JAMES	10 Victoria Street, S.W.
	1888 Feb. 7. 1901 Dec. 17.	MELHUISH, THOMAS WALTER WARREN	Dahlemerstrasse 6, Südende, Berl
	1874 May 5. 1891 Nov. 17.	MELLISS, JOHN CHARLES ..	264 Gresham House, Old Bro Street, E.C.
	1901 Apr. 23.	MELLOR, MONTAGUE RAFFINGTON	S. Pearson & Son, Coatzacoalc Mexico.
	1893 Mar. 7.	MELVILLE, WILLIAM	St. Enoch Station, Glasgow.
	1883 Dec. 4.	MENEZES, CAMILLO MARIA DE	Señor D. Level, 42 Rua da Passage Rio de Janeiro.
	1888 Mar. 6. 1896 Nov. 24.	*MESSENT, PHILIP GLYNN ..	Port Trust, Bombay.
	1879 Dec. 2. 1889 Jan. 29.	MESTAYER, RICHARD LIBON ..	Lambton Quay, Wellington, N.Z.
	1896 Mar. 3.	METCALF, WILLIAM	Braeburn Steel Co., Braeburn, P U.S.
	1885 Mar. 3. 1897 Apr. 6.	METCALFE, *Sir* CHARLES HERBERT THEOPHILUS, *Bart.*	5 Grand Parade Buildings, Ca Town, C.C.
	1892 Dec. 6. 1901 Dec. 11.	METCALFE, HENRY HULBERT	30 Palmerston Buildings, Aucklan N.Z.
	1875 Feb. 2. 1882 Feb. 14.	METHVEN, CATHCART WILLIAM, F.R.S.E.	Durban, Natal.
	1878 Feb. 5. 1894 Dec. 4.	*MEYSEY-THOMPSON, ARTHUR HERBERT	Hathorn, Davey & Co., Lee (Hathorn, Leeds. 524.)
	1874 Dec. 1. 1891 Dec. 8.	MICHELE, VITALE DOMENICO DE	Higham Hall, Rochester.
	1880 May 4. 1900 Jan. 30.	*MICHELL, THEOPHILUS	c.o. H. S. King & Co., 65 Cornhi E.C.
✠	1870 Feb. 1. 1885 Dec. 1.	MIDDLETON, REGINALD EMPSON	17 Victoria Street, S.W. (Appoi London.)
	1863 Mar. 3.	MIERS, FRANCIS CHARLES ..	Eden Cottage, Beckenham.
	1896 Feb. 4. 1902 Apr. 22.	*MILES, HARRY POWELL ..	Engineer's Office, Crigglesto Wakefield.
	1876 Mar. 7. 1886 Feb. 9.	MILLER, HENRY	Bosmere House, Norwich Roa Ipswich.
	1892 Mar. 1. 1899 Feb. 7.	MILLER, HERBERT WOODVILLE	Electric Lighting Works, Kensin ton Court, W.
	1869 May 11. 1878 Mar. 21.	MILLER, THOMAS	Dock Commission and Harwich Ha bour Conservancy Board, Ipswic
	1885 Dec. 1. 1899 Dec. 12.	*MILLER, THOMAS LODWICK ..	7 Tower Buildings North, Wat Street, Liverpool.
	1901 Apr. 23.	MILLS, FREDERICK	Ebbw Vale Steel, Iron and Co Co., Ebbw Vale, Mon.
	1898 Apr. 5.	MILLS, GRANVILLE	Kingslee, Farndon, Chester.
	1891 May 12.	MILLS, MANSFELDT HENRY ..	Mansfield-Woodhouse, Notts.
t ✠	1862 Apr. 1.	MILLS, WILLIAM HEMINGWAY ..	Nurney, Glenagarey, co. Dublin.
	1877 Dec. 4. 1889 Nov. 5.	*MILSOM, BOSWELL PARKINSON	Grindlay, Groom & Co., Bombay.

	Date of Election and of Transfer.	MEMBERS.	
T t ✠	1899 Dec. 5.	MILTON, JAMES TAYLER	Lloyd's Register, 71 Fenchurch Street, E.C.
	1891 May 5. 1895 May 14.	MIRRLEES, WILLIAM JULIUS, B.Sc. (*Glas.*)	Tongaat, Natal.
m ✠	1889 Feb. 5. 1894 May 22.	*MOIR, ERNEST WILLIAM	Great Northern & City Ry., Poole Street, New North Road, N.
✠	1889 Dec. 3.	MOLESWORTH, HENRY BRIDGES	39 Victoria Street, S.W.
W m ✠	1854 Mar. 7. 1862 Nov. 25.	MOLESWORTH, *Sir* GUILFORD LINDSEY, K.C.I.E. (*Vice-President.*)	39 Victoria Street, S.W.
	1872 May 7. 1887 May 24.	*MOLLETT, FREDERICK HERBERT	C. H. Walker & Co., 15 Great George Street, S.W.
	1889 Feb. 5. 1895 Apr. 9.	MOLLISON, JAMES SMITH	District Engineer, Orange, New South Wales.
	1896 Dec. 1.	MOLLOY, ROBERT ALFRED	c.o. H. S. King & Co., Pall Mall, S.W.
	1888 May 1.	MONCRIEFF, ALEXANDER BAIN	Eng.-in-Chief, Adelaide, S. Australia.
t ✠	1890 May 6. 1897 Jan. 19.	MONCRIEFF, JOHN MITCHELL	1 St. Nicholas Buildings, Newcastle-on-Tyne. (P.O. 10.)
	1887 May 24.	MONCRIEFF, JOSEPH COWAN BAIN	Ry. Station, Adelaide, S. Australia.
m ✠	1888 Feb. 7. 1902 Feb. 11.	*MONEY, ROBERT JARRATT	S. Pearson & Son, Shanghai.
	1875 Dec. 7. 1890 Nov. 11.	MONK, HUGH LEWIN	H. S. King & Co., Pall Mall, S.W.
✠	1894 May 22. 1899 Dec. 12.	MONKHOUSE, EDWARD WYNDHAM, M.A. (*Cantab.*)	14 Old Queen Street, Westminster, S.W.
	1878 May 28. 1893 Nov. 7.	*MONTAGUE, JOHN MONTHERMER, M.A. (*Oxon.*)	Lee House, Marwood, Barnstaple.
	1866 May 15.	MOORE, ALFRED	Holmleigh, Trafford Road, Alderley Edge.
	1891 May 5. 1898 Nov. 29.	*MOORE, ARTHUR MEYRICK	27 Woburn Place, Tavistock Square, W.C.
	1903 Mar. 3.	MOORE, GEORGE	Railway, Manila, Philippines.
	1880 Dec. 7. 1884 Mar. 4.	MOORE, GEORGE EDWARD	Hobart, Tasmania.
	1883 Dec. 4. 1895 Apr. 2.	*MOORE, RICHARD ST. GEORGE	17 Victoria Street, S.W.
	1887 Dec. 6.	MOORE, ROBERT	Laclede Building, St. Louis, Mo., U.S.
	1867 Jan. 8.	MOORSOM, LEWIS HENRY	20 Cooper Street, Manchester.
	1888 Jan. 10.	MORCOM, ALFRED	Ledsam Street Works, Birmingham.
	1904 Jan. 12.	MORDEY, WILLIAM MORRIS	82 Victoria Street, S.W.
✠	1866 Dec. 4. 1879 Apr. 29.	MORE, CHARLES JAMES	Thames Conservancy, Victoria Embankment, E.C.
✠	1886 Mar. 2. 1896 Dec. 22.	MORE, JAMES, JUN., F.R.S.E.	74 George Street, Edinburgh. (Theodolite, Edinburgh.)
✠	1881 Dec. 6. 1888 Feb. 7.	*MOREING, CHARLES ALGERNON	20 Copthall Avenue, E.C. (Bewick, London. London Wall 758.)
	1869 May 4.	*MORELAND, RICHARD	4 Highbury Quadrant, N. (Expansion, London.)
	1883 Jan. 9. 1889 Apr. 30.	MORGAN, CHARLES LANGBRIDGE	L. B. & S. C. Ry., London Bridge, S.E.
	1882 Dec. 5. 1891 May 12.	MORGAN, WALTER CAMPBELL DE	c.o. H. S. King & Co., Pall Mall, S.W.
	1892 Dec. 6.	MORGANS, THOMAS	60 Queen Square, Bristol.
✠	1902 Jan. 14.	MORISON, JOHN	Cramlington House, Northumberland.
	1892 May 24.	*MORLEY, GEORGE STREATFEILD	P.W.D., Jabalpur, C.P., India.
	1897 Apr. 6.	MORLEY, HENRY	Gasworks, Cardiff.
	1884 Dec. 2. 1889 May 21.	MORRIS, DAVID	c.o. H. S. King & Co., Pall Mall, S.W.
	1870 Feb. 1. 1878 Apr. 30.	MORRIS, FRANK	Stile House, Lyme Regis.
	1881 May 31.	MORRIS, THOMAS BACON	c.o. H. S. King & Co., Pall Mall, S.W.

Date of Election and of Transfer.	MEMBERS.	
t ✠ 1870 Mar. 1. / 1877 Dec. 11.	MORRIS, WILLIAM	Kent Waterworks, Deptford, S.E
1888 May 15. / 1904 Mar. 29.	*MORRIS, WILLIAM ROBERT ..	15 Alexandra Mansions, W Hampstead, N.W.
W t ✠ 1870 Feb. 1. / 1874 Nov. 17.	MORRISON, GABRIEL JAMES ..	7 The Sanctuary, Westminster, S.
✠ 1887 May 24. / 1900 Dec. 19.	*MORSE, AMYAS..	
1892 Mar. 1. / 1898 Mar. 1.	MORTON, DAVID HOME	180 Bath Street, Glasgow.
✠ 1872 Dec. 3.	MORTON, ROBERT	27 Hamilton Terrace, N.W.
m 1879 Feb. 4. / 1888 May 15.	*MOSS-BLUNDELL, ARTHUR SPENCE	Englefield Green, Surrey.
T t ✠ 1862 Jan. 14.	MOSSE, JAMES ROBERT	5 Clanricarde Gardens, Tunbri Wells.
1884 Dec. 2. / 1890 Apr. 29.	MOSTYN, ROBERT JOHN COURTENAY	Thames Conservancy, Victoria E bankment, E.C.
1895 Mar. 5.	MOTT, BASIL	2 Queen Square Place, Westmins S.W.
✠ 1885 May 5.	MOUNTAIN, ADRIEN CHARLES ..	City Surveyor, Melbourne, Victo
t ✠ 1880 Dec. 7. / 1890 Nov. 11.	*MOYLE, GEORGE	c.o. Alliance Bank of Simla, Calcut
1871 Apr. 4. / 1877 Nov. 27.	MUIR, EDWIN	21 Devonshire Street, Hig Broughton, Manchester.
1896 Feb. 4. / 1904 Feb. 23.	MUIRHEAD, WILLIAM	Pethick Brothers, 109 Victo Street, S.W.
1892 May 3.	*MULLALY, JOSEPH JOHN ..	c.o. H. S. King & Co., Pall Mall, S.
1888 Feb. 7.	MULVANY, CHRISTOPHER JOHN, B.A.I. (*Dubl.*)	County Surveyor's Office, Athlo Ireland.
1889 Dec. 3. / 1900 Feb. 20.	MURGATROYD, SAMUEL LEES..	G. C. Ry., London Road, Manches
1871 Dec. 5. / 1899 Jan. 24.	MURPHY, PHILIP EDWARD ..	132 Philip Lane, Tottenham.
1875 Dec. 7. / 1892 Nov. 1.	MURRAY, *Hon.* ALEXANDER ..	Colonial Engineer and Survey General, Singapore, S.S.
1891 Mar. 3.	MURRAY, FREDERICK CHARLES	c.o. Grindlay & Co., Parliam Street, S.W.
1874 Dec. 1. / 1896 Jan. 28.	MURZBAN, MUNCHERJI COWASJI, *Khan Bahadur*, C.I.E.	Gulestan, Murzban Road, Bomba
1896 Dec. 1. / 1902 Apr. 22.	MUSKER, ARTHUR	Tuebrook, Liverpool.
m 1876 Feb. 1. / 1882 Jan. 24.	*MYERS-BESWICK, WILLIAM BESWICK	14 Victoria Street, S.W.
1897 Dec. 7.	MYLES, THOMAS JOSEPH, B.A.I. (*Dubl.*)	Midland Great Western Railw Athlone, Ireland.

1902 Jan. 14.	NAIRN, CHARLES CAMERON ..	State Railways, Hobart, Tasmani
✠ 1898 Jan. 11.	NAPIER, ROBERT TWENTYMAN	75 Bothwell Street, Glasgow.
✠ 1847 Mar. 2. / 1859 Mar. 8.	NEATE, CHARLES	14 Victoria Street, S.W. (Trigon London.)
1894 May 22. / 1903 Dec. 22.	NEWBIGGING, JOHN GIBSON ..	Gas Department, Manchester.
1870 Apr. 5. / 1878 Apr. 30.	NEWBIGGING, THOMAS	Ardwell, Hale, Cheshire.
1882 Dec. 5. / 1896 Jan. 28.	NEWCOMBE, ALFRED CORNELIUS	19 Elms Avenue, Muswell Hill, N
1889 Feb. 5. / 1898 Nov. 29.	*NEWELL, THOMAS MONK ..	Dock Office, Hull.
1879 May 6. / 1891 Nov. 9.	NEWEY, JOSEPH	Chief Inspector of Public Wor Cape Town, C.C.

	Date of Election and of Transfer.	MEMBERS.	
	1894 May 22. 1902 Dec. 2.	NEWINGTON, FRANK ALFRED ..	4 Osborne Terrace, Edinburgh.
	1894 Feb. 6. 1899 Dec. 12.	NEWTON, CHARLES BUTTERWORTH	Whitehall Chambers, Carlisle.
	1894 Apr. 3.	NEWTON, CHARLES EDWARD ..	17 Cooper Street, Manchester.
	1885 Dec. 1. 1897 Nov. 30.	*NEWTON, WILLIAM GYLLICH ..	P.W.D., Rangoon, Burma.
	1873 Mar. 4. 1880 Mar. 2.	NICHOLAS, CHARLES EDWARD ..	Ry. Dept., Sydney, N.S.W.
	1886 Dec. 7. 1902 Dec. 16.	NICHOLS, HARRY BERTRAM ..	11 Victoria Street, S.W.
t ✠	1892 Feb. 2.	NICHOLS, OTHNIEL FOSTER ..	42 Gates Avenue, Brooklyn, N.Y. U.S.
	1888 Apr. 10. 1902 Mar. 18.	*NICHOLSON, GEORGE TAYLOR ..	Table Bay Harbour, Cape Town, C.C.
	1897 April 6. 1903 Feb. 10.	NICHOLSON, JOHN RUMNEY ..	Tanjong Pagar Dock Co., Singapore, S.S.
	1887 May 3. 1899 Nov. 28.	NICOL, ROBERT GORDON	Harbour Engineer, Aberdeen.
	1875 Dec. 7. 1879 Mar. 25.	NICOLLS, THOMAS JOHN FRANCIS, B.A. (*Dubl.*)	14 Bridge Street, Glasgow.
	1899 Apr. 11.	NICOLSON, JOHN THOMAS, D.Sc. (*Edin.*)	Municipal Technical School, Princess Street, Manchester.
	1882 Mar. 7.	NIGHTINGALE, WALTER HAWKINS	40 Windsor Road, Ealing, W.
	1889 Dec. 3.	NIVEN, THOMAS OGILVIE ..	131 West Regent Street, Glasgow.
	1901 Feb. 5.	NOBLE, ALFRED	501 West 120th St., New York, U.S.
L	1881 Dec. 6.	NOBLE, *Sir* ANDREW, *Bart.*, *Capt.* R.A. *ret.*, K.C.B., F.R.S.	Elswick Works, Newcastle-on-Tyne. (Elswick, Newcastle. 8.)
	1898 Mar. 1.	NOBLE, SAXTON WILLIAM ARMSTRONG	8 Great George Street, S.W.
	1886 Dec. 7. 1888 Oct. 30.	NORMAN, CHARLES ERNEST ..	Ry. Dept., Melbourne, Victoria.
	1886 Apr. 6. 1903 Dec. 22.	NORMAN, WALTER	18 Tressillian Road, St. John's, S.E.
	1892 May 3. 1901 Dec. 11.	*NORTH, MARJORIBANKS KEPPEL	Local Government Board, Whitehall, S.W.
	1877 Feb. 6. 1883 May 29.	NYSTRÖMER, CARL AUGUST BERNHARD	Avenida Alvear 324, Buenos Aires.
	1877 May 1. 1892 Feb. 23.	OAK, WILLIAM PERCIVAL ..	Quex Lodge, West End Lane Kilburn, N.W.
	1869 Jan. 9. 1872 Apr. 23.	O'CALLAGHAN, *Sir* FRANCIS LANGFORD, K.C.M.G., C.S.I., C.I.E.	Crichmere, Guildford.
	1876 Apr. 4. 1889 Jan. 15.	O'CONNELL, JOHN	Sion Villa, Kilkenny.
	1879 Apr. 1.	ODLING, CHARLES WILLIAM, C.S.I., M.E. (*Queen's*)	Craignoon, Ridgway Gardens, Wimbledon, S.W.
	1900 Jan. 9.	O'DONNELL, JOHN PATRICK ..	Palace Chambers, Westminster, S.W.
✠	1879 Feb. 4. 1891 Nov. 17.	OLIVE, WILLIAM THOMAS ..	32 Shortmarket Street, Cape Town, C.C.
	1889 Mar. 5. 1897 Nov. 30.	OLIVER, CALDER EDKINS, M.C.E. (*Melb.*)	Board of Works, Melbourne, Victoria.
	1889 Dec. 3. 1901 Dec. 11.	OLIVER, CHARLES DEANE, B.A.I. (*Dubl.*)	Congested Districts Board, 23 Rutland Square, Dublin.
	1878 Jan. 15. 1890 Nov. 25.	OLIVER, HENRY	Colombo, Ceylon.
	1895 Apr. 2. 1901 Feb. 12.	OLLEY, CHARLES HENRY ..	Engineer's Dept., Board of Works, Dublin.
	1884 Feb. 15. 1900 Jan. 30.	*O'NEILL, WILLIAM PURCELL	M. G. W. Ry., Broadstone Station, Dublin.
W t ✠	1897 Dec. 7.	ORAM, HENRY JOHN	Meadowside, Thurleigh Road, Balham, S.W.

	Date of Election and of Transfer.	MEMBERS.	
	1882 May 23. 1890 Apr. 15.	*ORANGE, FRANCIS	11 Gray's Inn Square, W.C.
✠	1882 May 23. 1890 Apr. 15.	*ORANGE, JAMES	Leigh & Orange, Hong Kong.
m	1896 Mar. 3.	*ORCHARD, WILLIAM PATTERSON, B.E. (*Queen's*)	County Surveyor, Ballina, co. M
	1873 May 20. 1879 Nov. 4.	ORMISTON, GEORGE EDWARD ..	9 Melbury Road, Kensington, W.
	1904 Jan. 12.	ORMSBY, CHARLES CROASDAILE	Wood Quay House, Galway.
	1891 Apr. 7. 1900 Apr. 3.	OSBORN, FRANK CHITTENDEN	Osborn Building, Cleveland, O U.S.
	1882 Jan 10. 1885 Feb. 10.	OSBORNE, JAMES	5 Dean Terrace, Liskeard, Cornw
	1865 Apr. 4.	OSBURN, HENRY	21 Cedars Road, Clapham Comm S.W.
	1894 Dec. 4.	O'SHAUGHNESSY, JAMES EDWARD	Bangalore, India.
	1891 May 5. 1904 Feb. 16.	OSMAN, CHARLES WILLIAM ..	S.E. & C. Ry., Works Dept., Tooley Street, S.E.
t ✠	1892 Dec. 6. 1901 Dec. 17.	*OSWELL, FRANK, B.A. (*Oxon.*)	Obras de los Graneros, Digue Buenos Aires.
	1883 Feb. 6.	OTWAY, JAMES, B.A. (*Dubl.*) ..	G. S. & W. Ry., Inchicore, Dubli
	1874 Jan. 13. 1882 Mar. 28.	OWEN, WILLIAM LANCASTER ..	26 Cornwall Gardens, S.W.
✠	1896 Dec. 1. 1902 Dec. 2.	OWLES, ARTHUR HATSELL ..	Admiralty Harbour Works, Dover
	1887 Apr. 5. 1903 Apr. 7.	*OXTOBY, WILLIAM	Borough Engineer, Camberwell, S
	1877 May 29. 1881 May 24.	PACKMAN, JONATHAN	Haling House, Waddon Road, Cr don.
	1891 Dec. 1. 1899 Nov. 28.	*PADDON, ARTHUR MATTHEWS	38 Victoria Street, S.W.
✠	1861 Dec. 3. 1871 Nov. 21.	PADDON, JOHN BIRCH	Drymma, Neath, Glamorgan.
m	1875 Feb. 2. 1891 May 12.	*PAGE, GEORGE EDWARD	32 Bark Place, Bayswater Hill, V
✠	1870 Feb. 1. 1877 May 8.	PAIN, ARTHUR CADLICK	17 Victoria Street, S.W.
	1884 Dec. 2.	PALLISER, HARRY GEORGE ..	Holmwood, Addlestone, Surrey.
	1887 Apr. 5.	PALMER, CHARLES GEORGE, C.I.E.	Alleyn Lodge, Alleyn Road, W Dulwich, S.E.
	1884 Dec. 2. 1899 Nov. 28.	*PALMER, CHARLES STUART RUSSELL	Engineer-in-Chief's Office, Per Western Australia.
	1890 Apr. 1. 1898 Nov. 29.	PALMER, FREDERICK	Port Commissioners' Office, Calcu
	1870 Dec. 6. 1879 Nov. 11.	PALMER, GEORGE	c.o. H. S. King & Co., Pall Mall, S
	1884 May 6. 1897 Nov. 30.	PALMER, PHILIP HENRY	Boro' Engineer, Hastings.
	1884 Feb. 5. 1896 May 19.	PARKER, CHARLES DONALD NAPIER	Dock Works, Leith, N.B.
	1890 Dec. 2. 1904 Mar. 29.	*PARKER, JAMES ALEXANDER, B.Sc. (*Glas.*)	S.E. & C. Ry., Engineer's D London Bridge, S.E.
	1886 Mar. 2.	PARKER, JOHN DUNLOP	146 West Regent Street, Glasgo
S t ✠	1889 Dec. 3.	PARKER, THOMAS	Manor House, Tettenhall, Wol hampton.
	1882 Mar. 7. 1891 May 12.	PARKES, BENJAMIN, M.E. (*Queen's*), F.C.H. ..	c.o. H. S. King & Co., Pall Mall, S
✠	1880 Dec. 7. 1891 Nov. 3.	*PARKES, CHARLES REGINALD ..	11 Tregunter Road, S.W.
	1900 Jan. 9.	PARRINGTON, MATTHEW WILLIAM	Hill House, Monkwearmouth.

	Date of Election and of Transfer.	MEMBERS.	
✠	1875 May 4. 1879 Mar. 4.	PARRY, EDWARD	28 Park Row, Nottingham.
	1875 Mar. 2. 1887 Feb. 8.	PARRY, JOSEPH	Municipal Offices, Liverpool.
	1887 Dec. 6. 1895 Oct. 22.	PARRY, WALTER	Waterworks, Cawnpore, India.
✠	1894 Jan. 9. 1899 Nov. 28.	PARRY, WILLIAM KAYE, M.A., B.A.I. (*Dubl.*)	63 Dawson Street, Dublin. (Parry, Dublin. 808.)
C ✠	1895 Mar. 5. 1896 Nov. 24.	PARSHALL, HORACE FIELD ..	Salisbury House, London Wall, E.C. (Abscissa, London. London Wall, 301.)
✠	1881 May 31. 1892 Dec. 13.	*PARSONS, *Hon.* CHARLES ALGERNON, F.R.S. (*Member of Council.*)	Holeyn Hall, Wylam-on-Tyne.
T m ✠	1876 May 30. 1883 May 8.	*PARSONS, *Hon.* RICHARD CLERE, M.A. (*Dubl.*)	39 Victoria Street, S.W.
	1892 Dec. 6.	PARSONS, WILLIAM BARCLAY ..	22 William Street, New York, U.S.
	1894 May 22. 1901 Apr. 16.	PARTRIDGE, GERALD WILLIAM	25A Cockspur Street, S.W.
	1869 May 4. 1879 Feb. 4.	PASSMORE, FRANK BAILEY ..	5 Laurence Pountney Hill, E.C. (Knarf, London.)
	1867 May 21.	PASSOS, FRANCISCO PEREIRA ..	34 Rua da Santa Luzia, Rio de Janeiro.
	1889 Mar. 5. 1898 Dec. 20.	PATCHELL, WILLIAM HENRY ..	60 St. Martin's Lane, W.C. (Gerrard 2807.)
✠	1876 Feb. 1. 1885 May 5.	PATERSON, MALCOLM MCCULLOCH	35 Manor Row, Bradford.
✠	1852 Feb. 3. 1871 Dec. 19.	PATERSON, PETER	248 Burger Street, Maritzburg, Natal.
	1881 Dec. 6. 1893 Nov. 7.	PATERSON, THOMAS ORMISTON	Gasworks, Birkenhead. (Paterson, Birkenhead.)
	1895 Apr. 2. 1897 Dec. 7.	PATERSON, WILLIAM ALEXANDER	Eng.'s Office, Caledonian Ry., Edinburgh.
✠	1877 May 1.	PATTERSON, ROBERT CHARLES	Varuna, Hobart, Tasmania.
	1883 May 1. 1889 Jan. 15.	*PAWLEY, RICHARD	Hull & Barnsley Ry., 9 Charlotte Street, Hull.
✠	1875 May 4. 1896 Dec. 15.	PAXMAN, JAMES NOAH	Standard Ironworks, Colchester. (Paxman, Colchester.)
	1887 Apr. 5. 1889 Dec. 17.	PEACE, GEORGE HENRY	Monton Grange, Eccles, Manchester.
	1880 May 4. 1899 Nov. 28.	PEACHE, JAMES COURTHOPE ..	Layer Marney Tower, Kelvedon. (Peache, Birch.)
	1884 Mar. 4.	PEACOCK, RALPH	Avon Castle, Ringwood, Hants.
	1891 Jan. 13. 1899 Jan. 17.	*PEAKE, ROBERT EDWARD ..	4 Great Winchester Street, E.C.
✠	1890 Dec. 2. 1900 Feb. 20.	*PEARCE, ALFRED	Avonmouth Docks, Bristol.
	1861 Apr. 9.	PEARCE, JOHN CHARLES	Boston Spa, Yorkshire.
✠	1871 Apr. 4. 1897 Feb. 2.	*PEARSALL, HOWARD DEVENISH	21 Parliament Hill, Hampstead, N.W.
	1897 Apr. 6.	PEARSON, FRED STARK	Columbia Building (Room 220), 29 Broadway, New York, U.S.
	1882 Feb. 7.	PEARSON, WILLIAM GREY ..	97 Cannon Street, E.C.
	1889 Feb. 5. 1900 Jan. 23.	*PEIRCE, ROBERT	Croft House, Roose, Barrow-in-Furness.
t ✠	1885 Feb. 3. 1891 Jan. 13.	*PENNY, EDMUND, C.I.E... ..	1 Helena Road, Ealing, W.
	1892 Dec. 6.	PENNY, LOUIS	The Cedars, East Grinstead.
✠	1874 Jan. 13. 1885 Feb. 24.	*PERRAM, GEORGE JAMES, C.I.E.	Hyderabad, Deccan, India.
	1895 Dec. 3.	PERRIN, CHARLES	12 Cadogan Court, S.W.
	1892 Dec. 6.	PERRY, JAMES, M.E. (*Queen's*)	County Surveyor, Galway.

Date of Election and of Transfer.		MEMBERS.	
	1888 Apr. 10.	PETERS, CHARLES JASPER ..	3 Manor Court Road, Hanwell, V
	1874 Dec. 1.	PETERSON, PETER ALEXANDER	Canadian Pacific Ry., Montreal.
S t ✠	1884 Feb. 5. 1894 Jan. 16.	*PETTIGREW, WILLIAM FRANK ..	Friars Dene, Abbey Road, Barr in-Furness.
	1890 Apr. 1.	PEW, ARTHUR	Auburn, Ala., U.S.
	1890 Mar. 4.	PHELAN, ALFRED BERNARD, B.A. (*Dubl.*)	22 Chichele Road, Cricklewood, N
	1873 Feb. 4. 1883 Apr. 24.	PHILLIPS, ARTHUR FREDERICK	38 Parliament Street, S.W. (U berto, London.)
	1892 Dec. 6.	PHIPPS, CHRISTOPHER EDWARD	13 Kenilworth Road, Ealing, W.
	1891 Feb. 3. 1899 Apr. 18.	PIDGEON, JOHN	Railway Dept., Coolgardie, West Australia.
	1895 Dec. 3. 1899 Nov. 28.	PILKINGTON, HERBERT	Sheepbridge Ironworks, Chesterfi
✠	1865 May 23.	PILKINGTON, WOODFORD ..	Brooklands Cottage, Blackhe Park, S.E.
	1874 May 5. 1884 Dec. 2.	PIMENTEL, JOAQUIM GALDINO	Rua dos Invalidos 95, Rio de Jane
	1892 Dec. 6.	PIRRIE, *Rt. Hon.* WILLIAM JAMES, P.C., LL.D. (*Royal*)	Queen's Island, Belfast.
t ✠	1877 Dec. 4. 1885 Dec. 8.	PITT, WALTER	Newark Foundry, Bath.
	1888 May 15.	PLATT, JOHN	Hyning, Carnforth.
	1882 Mar. 7. 1897 Mar. 2.	*PLATT, SAMUEL SYDNEY ..	Borough Engineer, Rochdale. (16
	1884 Dec. 2.	PLATTS, JOHN JOSEPH	Hyndford House, Inglemere Ro Forest Hill, S.E.
	1896 Dec. 1. 1902 Dec. 16.	PLEDGE, MARTYN FENWICK DE	Nitrate Railway, Iquique, Chili.
	1891 Dec. 1. 1895 Jan. 22.	POGSON, ALFRED LEE	Admiralty New Breakwaters, Mal
	1879 Mar. 6. 1895 Feb. 12.	*POLLARD, JOHN	31 Old Queen Street, Westminst S.W. (Piezometer, London.)
	1885 Feb. 3. 1894 Feb. 20.	*POLLARD-URQUHART, MONTAGU ALEXIS	29 St. Andrew Square, Edinbur (Meik, Edinburgh.)
	1894 May 22. 1899 Jan. 17.	POLLITT, HARRY	Fernlea, Bowdon, Cheshire.
	1865 May 23. 1889 Apr. 30.	PONTIFEX, EDMUND ALFRED ..	6 Cadogan Court Gardens, Cadog Place, S.W.
	1882 Dec. 5. 1903 Dec. 22.	POPKISS, RICHARD	Langley House, Langley Aven Surbiton.
	1900 Jan. 9.	PORTER, JOHN BONSALL	McGill University, Montreal.
✠	1877 Dec. 4.	POTTER, WILLIAM FURNISS ..	16 Park Row, Leeds.
✠	1878 Feb. 5.	*POWNALL, CHARLES ASSHETON WHATELY	53 Victoria Street, S.W. (Teste London. Victoria 778.)
T t ✠	1894 Jan. 9. 1904 Feb. 16.	*PREECE, ARTHUR HENRY ..	8 Queen Anne's Gate, S.W.
T t L F ✠	1859 May 24. 1871 Dec. 5.	PREECE, *Sir* WILLIAM HENRY, K.C.B., F.R.S. (*Past-President.*)	Gothic Lodge, Wimbledon, S (Westminster 420 and Wimble 18.)
✠	1888 Dec. 4. 1902 Feb. 11.	PRESCOTT, HARRY ERNEST, M.A. (*Cantab.*)	44 Kensington Square, W.
	1899 Feb. 7.	PREST, JOHN JOSEPH	Hardwick Hall, Castle Eden, D ham.
m	1879 May 27. 1889 May 21.	*PRESTON, ALFRED ELEY ..	34 Essex Street, Strand, W.C.
✠	1891 Mar. 3. 1898 Jan. 25.	PRESTON, FRANCIS JOHN	Jubblepur, C.P., India.
	1885 Feb. 3. 1893 Dec. 12.	PRICE, ALFRED DICKINSON, M.A.I. (*Dubl.*)	3 Fortfield Villas, Palmer Park, Dublin.
t ✠	1888 Dec. 4.	PRICE, JAMES, B.A.I. (*Dubl.*) ..	Harbour Office, Lapp's Quay, C
	1879 Dec. 2. 1897 Dec. 7.	*PRICE, JOHN	City Surveyor, Birmingham.

	Date of Election and of Transfer.	MEMBERS.	
✠	1865 Dec. 5.	PRICE, WILLIAM HENRY ..	8 Yarborough Road, Southsea.
T t W S ✠	1861 Apr. 9.	PRICE-WILLIAMS, RICHARD ..	6 Queen Anne's Gate, Westminster, S.W. (Spandrel, London.)
	1889 Dec. 3. 1903 Dec. 22.	*PRICE - WILLIAMS, SEYMOUR WILLIAM..	James Mansergh & Sons, 5 Victoria Street, S.W.
	1886 Feb. 2. 1896 Dec. 15.	*PRIEST, FRANK EDWARD ..	13 Harrington Street, Liverpool. (6889.)
	1886 Mar. 2. 1902 Apr. 15.	PRIESTLEY, CHARLES HENRY..	Waterworks Engineer, Cardiff.
	1863 Mar. 3. 1873 Dec. 6.	PRINCE, HENRY	11 Clanricarde Gardens, W.
	1883 May 29.	PRINDLE, FRANKLIN COGSWELL	Navy Dept., Washington, U.S.
	1904 Feb. 2.	PRINGLE, ALBERT JAMES ..	160 Hope Street, Glasgow.
	1890 May 6. 1904 Apr. 12.	*PRITCHARD, THOMAS	264 Gresham House, Old Broad Street, E.C.
	1877 May 29.	PROCTOR, JONAS	Mere Lawn, Bolton.
	1889 Dec. 3. 1902 Apr. 29.	*PROUSE, ARTHUR DUNCAN ..	Harbour Works, Colombo, Ceylon.
	1886 Jan. 12. 1898 Apr. 5.	PRYCE, HENRY JAMES	54 Filey Avenue, Stoke Newington, N.
	1896 Dec. 1. 1902 Dec. 16.	*PRYDE, JOHN	Fairview, Mountfield Road, Church End, Finchley, N.
	1883 Jan. 9. 1890 May 20.	*PURDON, HENRY ATWELL ..	14 Artillery Mansions, Victoria St., S.W.
	1860 Feb. 7.	PURSER, EDWARD	Ottoman Railway, Smyrna.
	1898 Dec. 6.	PYNE, *Sir* THOMAS SALTER, C.S.I.	c.o. G. Allan & Co., 13 Austin Friars, E.C.
	1873 Feb. 4. 1879 Jan. 7.	QUELCH, ROBERT JAMES ..	66 Bromfelde Road, Clapham, S.W.
	1870 Dec. 6.	QUICK, JOSEPH..	1 Great George Street, S.W.
	1875 Dec. 7. 1882 Mar. 28.	QUIGLY, RICHARD, M.A. (*Dubl.*)	Willowmore, Cape Colony.
✠	1870 Feb. 1. 1883 May 22.	QUINETTE DE ROCHEMONT, *Baron* EMILE THEODORE ..	Rue de Marignan 18, Paris.
	1863 Mar. 3.	RADFORD, GEORGE KENT ..	2312 Warring St., Berkeley, Cal., U.S.
	1891 Mar. 3. 1904 Mar. 22.	*RAILTON, ALAN	Tanjong-Pagar Dock Co., Singapore, S.S.
t ✠	1876 Apr. 4.	RAMSAY, JAMES	Listoke, St. Stephen's Road, Ealing, W.
	1881 Apr. 5.	RAMSDEN, JOHN	Dane Croft, Holmes Chapel.
	1864 Mar. 1. 1877 May 29.	RANSOME, ALLEN	1 James Street, Lincoln.
	1886 Jan. 12. 1898 Nov. 29.	*RANSOME, JAMES STAFFORD ..	Box 455, Johannesburg, Transvaal.
m ✠	1888 May 15. 1897 Nov. 30.	*RANSOME, LEWIS HENRY.. ..	Farndon, Newark-on-Trent.
	1895 Jan. 8.	RAWORTH, JOHN SMITH	46 Christchurch Road, Streatham Hill, S.W.
	1890 May 4. 1901 Dec. 11.	*RAYNES, THOMAS	Waterworks, Johannesburg, Transvaal.
	1891 Feb. 3.	REA, SAMUEL	Pennsylvania Rlrd., Broad Street Station, Philadelphia, Pa., U.S.
	1887 May 24.	REAY, THOMAS PURVIS ..	Airedale Foundry, Leeds.
	1902 Feb. 4.	REDNALL, FRANCIS THOMAS ..	Charing Cross, Euston & Hampstead Ry., 30 Euston Square, N.W.
	1873 Dec. 2. 1885 Dec. 1.	REE, HENRY STRUTT COLLETTE	New Dock Works, Cardiff Ry., Cardiff.

Date of Election and of Transfer.	MEMBERS.	
L 1870 Mar. 1.	REED, *Sir* EDWARD JAMES, K.C.B., F.R.S., M.P.	Broadway Chambers, Westmins S.W. (Carnage, London.)
✠ 1891 Dec. 1. 1902 Feb. 11.	*REED, HENRY ASHMAN	H.M. Dockyard Extension, G raltar.
1885 Dec. 1.	REES, ITHEL TREHARNE	Guildhall Chambers, Cardiff (Mining, Cardiff.)
1879 Feb. 4. 1886 May 11.	REES, TOGARMAH	Corn Exchange Chambers, Newp Mon.
1887 Dec. 6. 1903 Jan. 13.	REEVE, HENRY, C.M.G.	c.o. St. Stephen's Club, Westminst S.W.
1876 Jan. 11. 1880 Apr. 13.	REICHENBACH, OSCAR	The Hollies, Crawley, Sussex.
1868 Apr. 7.	REID, GEORGE LOWE	33 Montpellier Crescent, Brighto
1901 Mar. 5.	REID, HERBERT CARTWRIGHT	Superintending Civil Engine H.M. Dockyard, Malta.
1897 Jan. 12.	REID, HUGH	Neilson, Reid & Co., Hyde P Locomotive Works, Glasgow.
1886 Mar. 2. 1895 Oct. 22.	*REID, KENNETH	Ferrocarril, San José, Costa Rica
1862 May 6.	RENDEL, *Sir* ALEXANDER MEADOWS, K.C.I.E., M.A. (*Cantab.*)	8 Great George Street, S.W. (Su kur, London.)
1888 Dec. 4.	RENDELL, ALAN WOOD	82 York Road, King's Cross, N.
t ✠ 1857 Mar. 3. 1860 Mar. 6.	RENNIE, GEORGE BANKS ..	20 Lowndes Street, S.W.
1886 Apr. 6. 1902 Dec. 16.	*RENTON, ALEXANDER CRAIG, B.Sc. (*Edin.*)	Courtburn, Coldingham, Berwi shire.
✠ 1886 May 18.	RESTLER, JAMES WILLIAM ..	Southwark & Vauxhall Water C Southwark Bridge Road, S.E.
1887 Dec. 6. 1899 Feb. 7.	REUNERT, THEODORE	Box 92, Johannesburg, Transvaal
1879 May 6. 1892 Nov. 22.	*REYNOLDS, GEORGE BERNARD	c.o. Grindlay & Co., Parliam Street, S.W.
L t ✠ 1883 Dec. 4.	REYNOLDS, *Professor* OSBORNE, M.A. (*Cantab.*), LL.D. (*Glas.*), F.R.S.	Fallowfield, Manchester.
1875 Dec. 7. 1883 Nov. 6.	REYNOLDS, PLAYFORD	Bryncam, The Park, Cheltenham
1890 May 6.	RHODES, CHARLES EDWARD ..	Aldwarke Main Colliery, Rotherha
1887 Dec. 6. 1893 Nov. 7.	RHODES, JOHN HENRY HORACE WENTWORTH	Highfield, Beeston Royd, Leeds.
1897 Dec. 7.	RICE, EDWIN WILBUR, JUN. ..	Schenectady, New York, U.S.
1871 May 2. 1883 Nov. 20.	RICE, JAMES	The Nutshell, Cheam Road, Sutt Surrey.
1904 Feb. 2.	RICH, WILLIAM	Trevu, Camborne, Cornwall.
1878 May 7. 1889 Nov. 15.	RICHARD, HENRY JOSEPH ..	67 Gordon Road, Ealing, W.
1881 Apr. 5.	RICHARDS, EDWARD WINDSOR	Plâs Llecha, Tredunnock, Caerle Mon.
✠ 1888 Dec. 4. 1902 Jan. 28.	RICHARDS, RICHARD WATKINS ..	Mutual Life of New York Buildin Martin Place, Sydney, N.S.W.
1887 Jan. 11.	RICHARDS, THOMAS	Nundydroog Co., Oorgaum, Myso [Indi
1865 Feb. 7. 1879 Feb. 4.	RICHARDSON, JOHN	Well Royd, Rawdon, Leeds.
C ✠ 1894 Apr. 3.	RICHARDSON, JOHN	Globe Works, Lincoln.
1872 Dec. 3. 1887 Oct. 25.	RICHARDSON, WILLIAM PELHAM	Broadlands House, Brockenhur Hants.
1879 Mar. 4. 1882 Jan. 10.	RICHES, TOM HURRY	Taff Vale Railway, Cardiff.
1868 Apr. 7.	RICHMOND, DAVID, B.A. (*Dubl.*)	Victoria Place, Warrenpoint, Down.
1876 May 2. 1891 Nov. 3.	RICHMOND, JAMES	Govt. Rys., Kingston, Jamaica.

	Date of Election and of Transfer.	MEMBERS.	
	1904 Feb. 2.	RICKETTS, PALMER CHAMBERLAINE	Troy, New York, U.S.
	1896 Mar. 3. 1902 Mar. 18.	RIDER, JOHN HALL	L.C.C. Tramways, 303 Camberwell New Road, S.E.
t ✠	1866 Dec. 4. 1874 Nov. 17.	RIDLEY, WILLIAM	39 Victoria Street, S.W.
	1891 Dec. 1. 1901 Apr. 23.	*RIGBY, HERBERT PETER BARROW	Main Drainage, Cape Town, C.C.
	1876 Feb. 1. 1883 Mar. 13.	RIGBY, JASON, B.A. (*Dubl.*)	c.o. Buenos Aires and Rosario Ry. Co., 3A Coleman Street, E.C.
	1872 May 14. 1882 Nov. 7.	RIGG, HENRY	Alexander Fletcher & Co., 2 St. Helen's Place, E.C.
	1897 Dec. 7.	RILEY, WILLIAM EDWARD	London County Council, Spring Gardens, S.W.
t ✠	1893 Dec. 5.	RIPPER, *Professor* WILLIAM	University College, Sheffield.
m ✠	1880 May 25. 1901 Dec. 17.	*RITSO, BERNARD WILLIAM	P.W.D., Cape Town, C.C.
✠	1875 May 4. 1902 Mar. 11.	RIVERS, EDWARD GEORGE, I.S.O.	H.M. Office of Works, Storey's Gate, Westminster, S.W.
	1903 Mar. 3.	ROBERTS, DAVID EVAN	59 Queen Street, Cardiff.
	1884 Apr. 1. 1899 Dec. 12.	ROBERTS, MARTIN FENN	Mabshill, Epsom.
	1887 Mar. 1. 1896 Nov. 16.	ROBERTS, THOMAS	Govt. Rys., Adelaide, S. Australia.
	1870 May 3. 1879 Mar. 25.	ROBERTS, WILLIAM	831 Salisbury House, Finsbury Circus, E.C.
	1893 Feb. 7. 1898 Feb. 1.	ROBERTS, WILLIAM	Highland Ry., Inverness.
t ✠	1874 Dec. 1. 1890 Feb. 25.	ROBERTSON, FREDERICK EWART, C.I.E.	8 Great George Street, S.W. (Sukkur, London.)
	1887 Feb. 1. 1893 Apr. 18.	ROBERTSON, JAMES ROBERT	Fairkytes, Hornchurch, Essex.
m ✠	1889 Dec. 3. 1901 Feb. 19.	*ROBERTSON, LESLIE STEPHEN	28 Victoria Street, S.W. (Eyebolts, London.)
✠	1886 May 4. 1894 Dec. 11.	*ROBERTSON, ROBERT, B.Sc. (*Edin.*)	154 West George Street, Glasgow.
	1904 Jan. 12.	ROBINSON, ARTHUR WELLS	14 Phillip Square, Montreal, Canada.
	1893 Dec. 5.	ROBINOW, FRANK	4 Mount Street, Berkeley Square, W.
	1872 May 7. 1885 Dec. 15.	*ROBINSON, CHARLES EDWARD	Selborne, Ashburton, S. Devon.
	1875 Apr. 6. 1895 Jan. 8.	ROBINSON, FRANK EDWARD	13 Victoria Street, S.W.
t ✠	1864 Feb. 2. 1868 Feb. 18.	ROBINSON, *Professor* HENRY	Parliament Mansions, Victoria Street, S.W.
T t ✠	1866 Mar. 6. 1872 Apr. 30.	ROBINSON, JOHN	8 Vicarage Terrace, Kendal.
	1896 Jan. 14.	ROBINSON, JOHN FREDERICK	17 Victoria Street, S.W.
	1902 Jan. 14.	ROBINSON, JOHN GEORGE	Boothdale, Fairfield, Manchester.
	1893 May 2.	ROBINSON, MARK HEATON	Overslade, Rugby.
	1876 Dec. 5.	ROBINSON, ROBERT	Darlington.
	1884 May 27. 1900 Mar. 27.	ROBINSON, *Professor* WILLIAM, M.E. (*Queen's*)	Dalriada, Alexandra Park, Nottingham.
	1894 Dec. 4. 1903 Feb. 24.	ROBSON, JOHN JAMES	335 High Holborn, W.C.
	1885 May 19. 1895 May 14.	*ROBSON, OLIVER CLAUDE	Public Offices, Dyne Road, Kilburn, N.W.
	1875 May 11.	ROCHE, GEORGE BYLAND	146 Church Rd., Upper Norwood, S.E.
t ✠	1886 Feb. 2. 1901 Dec. 11.	ROECHLING, HERMAN ALFRED	39 Victoria Street, S.W.

	Date of Election and of Transfer.	MEMBERS.	
	1878 May 7.	ROFE, HENRY	8 Victoria Street, S.W. (Fill Rofe, London.)
✠	1878 May 7.	ROFF. GEORGE LENTON	44 Kensington Park Gardens, W
	1899 Dec. 5.	ROGERS, ARTHUR BURDEN CAMPBELL	Municipality, Agra, N.W.P., Ind
	1896 Dec. 1. 1902 Dec. 2.	ROGERS, HERBERT MALCOLM	Redcliffe, Durham Avenue, Broml Kent.
	1901 Mar. 5.	ROGERS, RICHARD BIRDSALL, B.A.Sc. (*McGill*)	Trent Canal, Peterborough, O Canada.
	1903 Jan. 13.	ROGERS, TOM HUGH GODDARD	The Dockyard, Liverpool.
m ✠	1885 Feb. 3. 1903 Mar. 31.	*ROOPER, WALTER OSMOND	Horcott House, Fairford, Glos.
	1880 Dec. 7.	ROSE, WILMOT JAMES	Govt. Rys., Cradock, Cape Colony
✠	1880 May 25.	ROSS, ALEXANDER (*Member of Council.*)	G. N. Ry., King's Cross, N.
	1882 Dec. 5. 1895 Jan. 15.	ROSS, DAVID JAMES	Engineer's Office, Guildhall, E.C
	1895 Dec. 3. 1903 Feb. 17.	ROSS, WILLIAM, B.E. (*Royal*)	56 Dallas Road, Lancaster.
	1888 Apr. 10. 1891 Jan. 20.	ROTHWELL-JACKSON, CHARLES LOXTON	Moorfield, Bolton. (34.)
	1895 Jan. 8. 1903 Dec. 22.	ROUNTHWAITE, RICHARD SEPTIMUS	3 Willis Street, Wellington, N Zealand.
	1860 Apr. 3.	ROUSE, HENRY JAMES	13 Sussex Place, Regent's Park, N.
	1894 Jan. 9.	ROUTH, REGINALD SAMUEL JOHN	Assam-Bengal Ry., Haflong, Cach India.
	1895 Feb. 5.	ROUTLEDGE, WILLIAM HENRY	Woodfield Park, Blackwood.
	1898 Dec. 6.	ROWAN, JAMES	231 Elliot Street, Glasgow.
✠	1895 Feb. 5. 1902 Dec. 2.	ROWBOTHAM, JAMES MCKEAN	Calle Corrientes 951, Buenos Air
t ✠	1888 Dec. 4.	ROWLANDSON, CHARLES ARTHUR	Great Central Ry., Manchester.
	1884 Dec. 2.	ROWLEY, WALTER	20 Park Row, Leeds. (Wal Rowley, Leeds.)
	1881 Dec. 6. 1896 Mar. 10.	RUMSBY, ERNEST JAMES	13 Landgrove Road, Wimble Park.
	1875 Dec. 7.	RUNDALL, JAMES WILLIAM	60 Marlborough Mansions, W Hampstead, N.W.
	1881 Dec. 6.	RUSSELL, JOHN	15 Victoria Street, S.W.
	1885 Feb. 3.	RUSSELL, NORMAN SCOTT	39 Coleman Street, E.C.
	1888 Feb. 7.	RUTTAN, HENRY NORLANDE	City Engineer, Winnipeg, Canada
✠	1886 Apr. 6. 1901 Feb. 19.	*RUTTER, HENRY FILLMER	West Middlesex Waterworks, Ha mmersmith, W.
	1884 May 6.	RYAN, JOHN HENRY, M.A. (*Dubl.*)	22 Nassau Street, Dublin. (Mi Dublin.)
	1887 Dec. 6.	RYAN, ROBERT HENRY	c.o. Agent-General for N.S. Victoria Street, S.W.
	1894 May 1.	SADLER, HENRY WILLIAM	G.N.Ry., Eng.'s Office, King's Cross,
	1881 May 31. 1903 Feb. 10.	*ST. CLAIR, *Hon.* LOCKHART MATTHEW, C.I.E.	Grindlay & Co., Parliament St., S.
✠	1877 Feb. 6. 1887 Feb. 1.	ST. GEORGE, PERCIVAL WALTER	151 St. James's Street, Montre Canada.
	1887 May 24.	SAISE, WALTER, D.Sc. (*Lond.*).	East Indian Ry., Giridih, Bengal
	1904 Jan. 12.	SALMON, CHARLES	"Oakhurst," Erith, Kent.
	1878 Apr. 2. 1879 Apr. 8.	SALTER, JOHN	10 Montrose Avenue, Redla Bristol.
	1888 Dec. 4. 1893 Mar. 28.	SAMPSON, JOHN	36 Victoria Street, S.W.
T t ✠	1869 May 4.	SAMUELSON, *Right Hon. Sir* BERNHARD, *Bart.*, P.C., F.R.S.	56 Prince's Gate, S.W.
	1882 Dec. 5. 1893 Mar. 14.	SAMUELSON, ERNEST	Bodicote Grange, Banbury.

Date of Election and of Transfer.	MEMBERS.	
T t ✠ 1866 Dec. 4. / 1894 Nov. 7.	SANDBERG, CHRISTER PETER ..	9 Bridge Street, Westminster, S.W. (Sandberg, London.)
C ✠ 1888 Feb. 7. / 1897 Jan. 12.	*SANDEMAN, EDWARD	Derwent Valley Water Board, Bamford, Sheffield.
✠ 1873 Feb. 4.	SANDEMAN, JOHN WATT ..	2 St. Nicholas Buildings, Newcastle-on-Tyne.
1881 Feb. 1.	SANDIFORD, CHARLES, C.B. ..	Uganda Ry., Mombasa, East Africa.
✠ 1890 Dec. 2. / 1896 Nov. 24.	*SANER, JOHN ARTHUR	Weaver Navigation, Northwich.
T t ✠ 1895 Feb. 5.	SANKEY, MATTHEW HENRY PHINEAS RIALL, *Capt.* R.E. *ret.*	Victoria Works, Rugby.
1882 Dec. 5.	SANTOS, JOSÉ AMERICO DOS ..	Caixa 748, Rio de Janeiro. (Zamerico, Rio.)
✠ 1876 Jan. 11. / 1880 Dec. 21.	*SAWYER, ERNEST EDWARD, M.A. (*Cantab.*)	20 Devonshire Terrace, Lancaster Gate, W.
1877 May 29. / 1887 Nov. 15.	SAWYER, FREDERIC HENRY READ	Engenho "Villa Raffard," Capivary, São Paulo, Brazil.
1885 May 19.	SCHENK, AUGUSTUS OSWALD ..	Harbour Office, Swansea.
1896 Feb. 4.	SCHNOOR, EMILIO ARMANDO HENRIQUE	Rua S. Bento 30, São Paulo, Brazil.
1891 Feb. 3.	SCHUYLER, JAMES DIX	Stimson Building, Los Angeles, California, U.S.
1883 Dec. 4. / 1888 Feb. 21.	SCOONES, THOMAS JAMES ..	3 Unity St., College Green, Bristol.
1889 May 21. / 1901 Feb. 19.	*SCORGIE, NORMAN	Town Hall, Hackney, N.E.
1897 Apr. 6.	SCORRAR, JORGE BLACK ..	Rua Duque de Caxias 20, São Paulo, Brazil.
t ✠ 1890 Apr. 1. / 1897 Mar. 2.	SCOTT, ADAM	Admiralty Works, Gibraltar.
1896 Dec. 1.	SCOTT, FREDERICK WILLIAM MORTIMER	P.W.D., Nagpur, C.P., India.
1892 Feb. 2. / 1900 Dec. 18.	SCOTT, GEORGE HALL	Keyham Dockyard Extension, Devonport.
1901 Apr. 2.	SCOTT, JOHN	District Engineer, Port Commission, Calcutta.
1870 May 3.	SCOTT, PETER	S. Mahratta Ry., Dharwar, Bombay.
1888 Jan. 10. / 1899 Dec. 12.	*SCOTT, *Professor* ROBERT JULIAN	Canterbury College, Christchurch, N.Z.
1872 May 7.	SCOTT, WALTER HENRY ..	Park Road, East Molesey.
1891 Feb. 3.	SCOTT, WILLIAM BELLHOUSE ..	Eversley Cottage, Middleton, Lancs.
1870 Dec. 6. / 1877 Oct. 30.	SCOTT, WILLIAM GEORGE ..	26 Dingle Lane, Liverpool.
1873 Jan. 14. / 1885 Dec. 15.	SCOTT, WILLIAM HENRY ..	Casterton, Victoria.
✠ 1885 Dec. 1.	SEATON, ALBERT EDWARD ..	32 Victoria Street, S.W. (Seaquake, London. Victoria 207.)
1881 Jan. 11. / 1892 Mar. 15.	SEATON, EDWARD PARKE ..	Metropolitan Railway, 32 Westbourne Terrace, W.
1880 Dec. 7.	SELFE, NORMAN	279 George Street, Sydney, N.S.W.
1884 May 6.	SELLERS, COLEMAN, D.E. (*Stevens Inst., N.J., U.S.*) D.Sc. (*Penn.*)	1304 Stephen Girard Building, Philadelphia, U.S.
1887 Dec. 6.	SELLERS, WILLIAM	Philadelphia, U.S.
1886 Mar. 2. / 1903 Dec. 22.	SELLON, STEPHEN PRESCOTT WHITE D'ALTE	36 Victoria Street, S.W.
1882 Feb. 7. / 1895 Nov. 5.	*SELLS, CHARLES DE GRAVE ..	Cornigliano, Ligure, Italy.
1864 Feb. 2.	SEWELL, PHILIP EDWARD ..	Clare House, Norwich.
1878 Feb. 5. / 1896 Feb. 11.	SEWELL, WILLIAM	Manor Office, North Bridge Street Sunderland.
T t ✠ 1880 Jan. 13.	SEYRIG, THEOPHILUS	43 Rue de Rome, Paris.
1877 May 29. / 1890 Nov. 11.	*SHADBOLT, ERNEST IFILL ..	Grindlay, Groom & Co., Bombay.

Date of Election and of Transfer.	MEMBERS.	
T t ✠ 1893 Dec. 5.	SHANKLAND, EDWARD CLAPP	The Rookery, Chicago, Ill., U.S
1880 May 4. 1896 Feb. 25.	*SHARP, FREDERICK	c.o. H. S. King & Co., 65 Corn E.C.
1877 Dec. 4. 1882 Feb. 14.	SHAW, ARTHUR EDMUND ..	Sumner & Co., Paseo de Julio Buenos Aires, Argentina.
1894 Feb. 6. 1904 Apr. 19.	SHAW, PERCY WILLIAM	Tramway Construction Dept., ney, N.S.W.
1879 Feb. 4. 1899 Mar. 7.	*SHAW, SAM	Dewsbury.
✠ 1902 Jan. 14.	SHAW, WILLIAM ROBERT, M.E. (*Royal*)	152 Church Road, Upper Norw S.E.
t ✠ 1845 May 6. 1877 May 8.	SHEARS, WILLIAM	23 Kempshott Road, Streatham,
1885 Dec. 1. 1894 Nov. 6.	SHEDLOCK, OCTAVIUS JAMES..	Grindlay & Co., Parliament S.W.
✠ 1856 Apr. 1. 1859 Dec. 6.	SHEILDS, FRANCIS WEBB WENTWORTH-	Brentwood, Sholing, Southampt
1892 Jan. 12. 1900 Dec. 19.	SHELDON, WILLIAM JOHN ..	São Paulo Ry., São Paulo, Braz
✠ 1897 Mar. 2. 1902 Feb. 11.	*SHELFORD, FREDERIC, B.Sc. (*Lond.*)..	35A Great George Street, (Usefulness, London.)
T t W ✠ 1866 Apr. 10.	SHELFORD, *Sir* WILLIAM, K.C.M.G. (*Member of Council.*)	35A Great George Street, (Usefulness, London.)
✠ 1882 Dec. 5. 1892 May 3.	*SHELLSHEAR, WALTER	Ry. Dept., Bridge Street, Syd N.S.W.
1888 Feb. 7. 1893 Apr. 18.	SHERLOCK, HENRY ALEXANDER GEORGE..	G. E. Ry., Cambridge.
1875 Dec. 7. 1882 Nov. 7.	SHERMAN, WILLIAM HANBURY PETTINGAL	Grindlay & Co., Parliament St.,
1885 Dec. 1. 1901 Dec. 11.	*SHIELD, ARTHUR HINDHAUGH .	35A Great George Street, S.W.
1866 Jan. 9. 1870 Dec. 6.	SHIELD, HENRY	Fawcett, Preston & Co., Liverp
✠ 1871 Mar. 7. 1879 Jan. 14.	*SHIELD, WILLIAM, F.R.S.E. ..	33 Old Queen Street, Westmin S.W.
1889 May 7.	SHIELD, WILLIAM	19 North Side, Clapham Comm S.W.
t ✠ 1864 Feb. 2. 1876 May 9.	SHOOLBRED, JAMES NELSON, B.A. (*Lond.*)	47 Victoria Street, S.W.
1891 Dec. 1. 1900 Jan. 23.	*SHOOSMITH, HARRY..	Wynford, Abbey Wood, Kent.
1877 Dec. 4. 1890 Mar. 18.	*SHORES, JOHN WALLIS, C.M.G.	Chief Engineer, Govt. Rys., Ma burg, Natal.
1877 May 1. 1893 Mar. 28.	SHORTT, CHARLES HENRY ..	Bramcote, Bramcote Road, Put S.W.
1887 Dec. 6. 1896 Mar. 31.	*SIBBERING, GEORGE THOMAS ..	Engineer, Taff Vale Railway, diff.
t ✠ 1869 Feb. 2. 1879 Jan. 28.	SICCAMA, HAROO THEODORUS HORA	Yvoire par Nernier, Haute Sa France.
1873 Feb. 4. 1890 Nov. 25.	*SIEMENS, ALEXANDER (*Member of Council.*)	12 Queen Anne's Gate, S.W. mens, London. Westminster
T t ✠ 1870 May 24.	SIEMENS, CARL	
1887 Feb. 1. 1901 Feb. 26.	*SILCOCK, EDWARD JOHN.. ..	10 Park Row, Leeds. (Theod Leeds.)
1888 Apr. 10. 1897 Nov. 30.	*SILK, ALBERT EDWARD ..	Bengal Secretariat, Calcutta.
1879 Feb. 4. 1888 Feb. 14.	SILVA, DOMINGOS SERGIO DE SABOIA E	Rua Christovão Colombo, Ri Janeiro.
1880 Feb. 3. 1891 Dec. 8.	SIM, CHARLES LOUIS	Cranbourne Lodge, Hendon, N.
1883 May 1. 1890 Nov. 11.	SIMMONS, JOHN	Bank Chambers, Doncaster.

Date of Election and of Transfer.	MEMBERS.	
1881 May 3.	SIMON, FREDERICK	4 Colville Gardens, Bayswater, W.
1868 Feb. 4. 1874 Apr. 14.	SIMPSON, ARTHUR TELFORD ..	38 Parliament Street, S.W.
1875 Jan. 12. 1888 Jan. 17.	SIMPSON, BENJAMIN CRISPIN ..	5 Westminster Palace Gardens, Victoria Street, S.W.
1882 May 2. 1893 Feb. 7.	SIMPSON, DAVID CARNEJY ..	Govt. Rys., Redfern, Sydney, N.S.W.
1890 Dec. 2. 1903 Feb. 10.	SIMPSON, EDWARD MARSH ..	c.o. H. B. Simpson, 79 Platts Lane, Hampstead, N.W.
1885 May 19.	SIMPSON, JAMES THOMAS ..	34 St. Charles Square, N. Kensington, W.
✠ 1870 Feb. 1.	SIMPSON, JOHN BELL	Bradley Hall, Wylam-on-Tyne.
1904 Jan. 12.	SIMS, THOMAS	8 Alleyn Road, Dulwich, S.E.
1887 Mar. 1. 1897 Nov. 30.	*SIMSON, DAVID	Casilla de Correo 741, F.C. Oeste, Buenos Aires.
1879 Dec. 2. 1885 Nov. 10.	SINGLE, JOHN GODFREE	1 The Esplanade, Plymouth.
1876 Mar. 7. 1888 Nov. 27.	*SKETCHLEY, HENRY GOULTON	F. C. del Sud, Buenos Aires.
1861 Dec. 3. 1865 Jan. 17.	SLESSOR, FREDERICK GEORGE	Easterlands, Wellington, Somerset.
1888 Feb. 7.	SMAIL, JOHN MOORE	Water Supply & Sewerage Dept., Sydney, N.S.W.
1897 Dec. 7.	SMALL, FREDERICK HENRY ..	Wellington Street, Bondi, Sydney, N.S.W.
1886 Feb. 2. 1899 Jan. 17.	*SMELT, JOHN DANN	River Plate House, Finsbury Circus, E.C. (Smelt, London. London Wall 1000.)
1882 Dec. 5. 1888 Nov. 20.	SMIJTH, EDMUND CASWELL BOWYER	53 Rue du Chatelain, Avenue Louise, Brussels.
1876 May 30. 1878 May 14.	SMITH, ALEXANDER	3 Newhall Street, Birmingham.
1894 Dec. 4. 1902 Apr. 29.	*SMITH, ALEXANDER ARTHUR DALRYMPLE, M.Sc. (*Durham*)	12 Claremont Terrace, Sunderland.
1882 Mar. 7. 1900 Mar. 27.	SMITH, ARTHUR KEEN	Chartham, Lonsdale Road, Barnes, S.W.
1885 Feb. 3. 1901 Dec. 11.	*SMITH, CECIL ARCHIBALD ..	Trevandrum, Travancore, India.
1885 Jan. 13. 1895 Oct. 22.	SMITH, CHARLES WALTER ..	Metropolitan Board of Water Supply and Sewerage, Sydney, N.S.W.
1887 Feb. 1. 1904 Apr. 19.	SMITH, CYRIL	F.C. Central, Asuncion, Paraguay.
1877 Feb. 6. 1891 Jan. 27.	SMITH, EDWARD BLAKEWAY ..	Canal Engineer's Office, Trent & Mersey Navigation, Stoke-on-Trent.
1889 May. 7. 1895 Mar. 26.	*SMITH, EDWARD MARTIN ..	L. & N.W. Ry., Vauxhall, Birmingham.
1872 May 7. 1879 Nov. 11.	SMITH, FRANCIS FREDERICK ..	South Indian Railway, Trichinopoly.
t ✠ 1893 Dec. 5. 1903 Feb. 17.	*SMITH, HAROLD DUKE	Engineer's Office, G.W. Ry., Paddington, W.
1884 Dec. 2. 1893 Nov. 14.	SMITH, HENRY	101 Grosvenor Road, S.W.
1887 Feb. 1. 1889 May 14.	SMITH, HENRY BADELEY ..	Rossland, British Columbia.
1881 Dec. 6. 1896 Mar. 17.	*SMITH, HERBERT BLOMFIELD	44 Alleyn Road, West Dulwich, S.E.
1891 May 5. 1897 Jan. 12.	*SMITH, JOHN, B.E. (*Royal*) ..	County Surveyor, Ballinaslce, Ireland.
t ✠ 1868 Mar. 3.	SMITH, JOSIAH TIMMIS	Rhine Hill, Stratford-on-Avon.
✠ 1866 May 1. 1874 May 5.	SMITH, MARCUS	Ottawa, Canada.
1874 Apr. 14. 1902 Dec. 2.	SMITH, URBAN ARMSTRONG ..	41 Parliament Street, S.W. (Urban Smith, London.)

	Date of Election and of Transfer.	MEMBERS.	
✠	1885 Dec. 1. / 1892 Nov. 1.	SMITH, WALTER ALEXANDER	Roads & Bridges Dept., Syd N.S.W.
✠	1874 Jan. 13.	SMITH, WILLIAM	Gatelands South Drive, Vict Park, Wavertree, Liverpool.
	1877 Jan. 16. / 1889 Jan. 15.	SMITH, WILLIAM ARCHIBALD ..	Punchard, Lowther&Co.,151 Can Street, E.C.
	1891 Jan. 13. / 1901 Mar. 5.	SMITH, WILLIAM CHARLES CLIFFORD	6 Waterloo Place, S.W.
	1903 Feb. 3.	SMITHE, EDMUND DU CANE	Lahore, Punjab.
	1884 Dec. 6.	SMYTH, WILLIAM STOPFORD ..	Royal Societies Club,St. James's S.W.
	1889 Mar 5.	SMYTHE, THOMAS DIXON ..	Estacion Central, Santiago, Chil
	1895 Mar. 5. / 1903 Dec. 22.	*SNELL, JOHN FRANCIS CLEVERTON	Electricity Station, Sunderland.
	1883 Mar. 6.	SOARES, JOÃO TEIXEIRA	Banco do Commercio, Rio de Jane
	1880 Apr. 6.	SOPWITH, ARTHUR	Chasetown, Walsall.
	1904 Jan. 12.	SOWARSBY, JOHN WILLIAM ..	Harbour Board, East London, So Africa.
✠	1875 May 4.	SPAGNOLETTI, CHARLES ERNEST PAÖLO DIANA	16 Frognal Lane, Hampstead, N
	1894 Mar. 6. / 1900 Jan. 30.	SPARKS, CHARLES PRATT ..	Bayonne, Ditton Hill, Surbiton.
✠.	1867 Dec. 3.	SPENCER, JOHN FREDERICK ..	91 Haworth's Buildings, Manch ter. (Concentration, Manchest
	1883 Jan. 9. / 1902 Jan. 28.	*SPINKS, WILLIAM	39 Prudential Buildings, Leeds.
	1882 May 23. / 1896 May 12.	SPOONER, CHARLES EDWIN, B.A.I. (*Dubl.*), C.M.G. ..	States Railways, Kuala Lump Selangore, S.S.
	1895 Mar. 5.	SPRAGUE, FRANK JULIAN ..	15 Wall Street, New York, U.S.
✠	1881 Dec. 6. / 1885 May 19.	SPRING, FRANCIS JOSEPH EDWARD, C.I.E.	Consulting Engineer for Railwa Madras.
	1904 Jan. 12.	*SPYER, ARTHUR	Oriel House, Farringdon Street,E
	1889 May 7.	*SQUIRE, WILLIAM WILKINSON	Docks, Cumberland Basin, Brist
	1882 Feb. 7. / 1885 Feb. 3.	STABLES, HENRY LEONARD ..	
	1877 Dec. 4. / 1884 Oct. 14.	STAFFORD, FREDERICK	Midland Railway, Perth, West Australia.
	1891 Dec. 1. / 1900 Dec. 18.	*STANFIELD, *Professor* RICHARD, F.R.S.E.	Heriot-Watt College, Edinburgh
	1897 Feb. 2.	STANKE, JULIUS	Caixa 347, Rio de Janeiro.
T t ✠	1877 May 29.	STANLEY, HENRY CHARLES (*Member of Council.*)	Mutual Provident Chambers, Edw Street, Brisbane, Queensland.
	1859 Dec. 6.	STANLEY, WALMSLEY	The Knowle, Leigham Court Ro Streatham, S.W.
	1886 Dec. 7. / 1901 Feb. 5.	*STANSFELD, ALFRED WOLRYCHE	10 Middleton Villas, Ilkley.
✠	1892 Dec. 6.	STANTON, ROBERT BREWSTER, M.A. (*Maimi Univ., Ohio*)	66 Broadway, New York, U.S.
	1904 Apr. 12.	STARKEY, FRANK	117 St. George's Street, Cape To
	1883 Dec. 4.	STAUFFER, DAVID McNEELY ..	St. Paul Building, New York, U.
m ✠	1878 Apr. 2. / 1884 Nov. 25.	STAYTON, GEORGE HENRY ..	Kiama, Cedar Road, Sutton, Surr
	1870 Feb. 1. / 1881 May 3.	STEAD, WALKER	County Surveyor, Northallerton.
	1902 Dec. 2.	STEADMAN, JAMES HARDIE, M.A.I. (*Dubl.*)	County Surveyor, Donegal.
	1892 Dec. 6.	STEAVENSON, ADDISON LANGHORNE	Durham.
W ✠	1900 Mar. 6.	STEIGER, ALPHONSE	28 Victoria Street, S.W.
	1896 Dec. 1.	STELFOX, JAMES	Gasworks. Belfast.
	1886 Dec. 7. / 1903 Feb. 17.	STEPHENS, FREDERICK ORLANDO	Pauling & Co., Box 713, Cape To C.C.

	Date of Election and of Transfer.	MEMBERS.	
S ✠	1881 Jan. 11. / 1894 Jan. 9.	*STEPHENS, GEORGE HENRY, C.M.G.	Oaklea Warren, Newick, Sussex.
	1853 May 24.	STEPHENSON, GEORGE ROBERT (*Past-President.*) ..	Ben Braich, Tilehurst Rd., Reading.
	1883 Feb. 6.	STEVENS, HENRY WANSBOROUGH	12 Old Post Office Street, Calcutta.
✠	1887 Feb. 1. / 1891 Apr. 28.	STEVENSON, CHARLES ALEXANDER, B.Sc.(*Edin.*), F.R.S.E.	84 George Street, Edinburgh.
t m ✠	1884 May 6. / 1886 Dec. 7.	STEVENSON, DAVID ALAN, B.Sc. (*Edin.*), F.R.S.E. ..	84 George Street, Edinburgh.
	1881 Mar. 1. / 1889 Jan. 22.	STEVENSON, EDMUND HERBERT	38 Parliament Street, S.W. (Holometer, London.)
	1881 Mar. 1. / 1889 Jan. 22.	STEVENSON, FLETCHER WILSON	Gasworks, Coventry.
	1897 Feb. 2.	STEWART, ABRAHAM McCAUSLAND, B.A.I. (*Dubl.*)	Shipquay Street, Londonderry.
	1890 May 20. / 1898 Apr. 26.	STEWART, ALEXANDER	J. W. Stewart, 150 Hope Street, Glasgow.
✠	1883 Apr. 3. / 1900 Mar. 26.	STEWART, CHARLES EDWARD ..	Govt. Rys., Humansdorp, Cape Colony.
	1868 Jan. 14. / 1877 Mar. 27.	STEWART, JAMES	Auckland, N.Z.
	1880 May 25.	STEWART, JOHN TIFFIN	Haumoana, Aramoho, Wanganui, N.Z.
m ✠	1883 Feb. 6. / 1893 May 2.	*STEWART, THOMAS	6 St. George's Chambers, Cape Town, C.C.
	1877 May 29. / 1883 May 1.	*STILEMAN, FRANK	1 Victoria Street, S.W. (Victoria, 1892.)
	1886 Dec. 7.	STIRLING, JAMES	Belmore, Ashford, Kent.
	1891 Feb. 3.	STIRLING, MATTHEW	Hull & Barnsley Ry., Spring Head, Hull.
✠	1898 Jan. 11.	STIRLING, ROBERT	The Anchorage, Dorman's Park, East Grinstead.
	1894 Dec. 4.	STIRRAT, JOHN	Ogilvy, Gillanders & Co., 67 Cornhill, E.C.
	1891 May 5. / 1898 Nov. 29.	STOCKMAN, BENJAMIN	Hey Tor, Torrington Park, North Finchley, N.
	1855 Mar. 6. / 1880 Feb. 10.	STOCKMAN, BENJAMIN PRYOR	82 Victoria Street, S.W.
t m ✠	1885 Dec. 1. / 1902 Dec. 16.	*STOKES, FREDERICK WILFRID SCOTT	32 Victoria Street, S.W.
T t ✠	1858 Jan. 12. / 1863 Nov. 17.	STONEY, BINDON BLOOD, LL.D. (*Dubl.*), F.R.S... ..	14 Elgin Road, Dublin.
t ✠	1875 May 4.	STONEY, EDWARD WALLER, M.E. (*Queen's*), C.I.E. ..	Chief Engineer, Madras Railway, Royapuram, Madras.
	1896 Feb. 4. / 1900 Dec. 19.	STONEY, GEORGE GERALD ..	Oakley, Heaton Road, Newcastle-on-Tyne.
	1886 May 18. / 1893 Oct. 3.	*STOREY, WILLIAM JOHN PATRICKSON	Darwen Iron Co., Mostyn, Flints.
	1876 Feb. 1.	STORY, JOHN SOMES	Market Place, Derby.
	1861 Dec. 3. / 1877 Oct. 30.	STOTHERT, GEORGE KELSON ..	Steamship Works, Bristol.
	1888 Dec. 4. / 1900 Jan. 30.	*STOTHERT, PERCY KENDALL ..	The Grange, Bradford-on-Avon.
✠	1886 Jan. 12. / 1894 Nov. 27.	STRACHAN, GEORGE RICHARDSON	7 Victoria Street, S.W.
	1892 Jan. 12. / 1899 Dec. 12.	STRACHEY, RICHARD SHOLTO ..	17 Clifton Park, Clifton, Bristol.
	1875 May 4. / 1882 Mar. 7.	STRAIN, JOHN .. .. .. (*Member of Council.*)	154 West George Street, Glasgow.
t ✠	1883 May 29. / 1898 Nov. 29.	*STRANGE, WILLIAM LUMISDEN	Box 557, Pretoria, Transvaal.
	1876 May 2. / 1877 Nov. 27.	STRIDE, ARTHUR LEWIS ..	L. T. & S. Ry., Fenchurch St., E.C. (Letser, London. Avenue 4376.)
	1889 Apr. 2.	STROBEL, CHARLES LEWIS ..	1744 Monadnock Block, Chicago, Ill., U.S.

	Date of Election and of Transfer.	MEMBERS.	
T t ✠	1885 Dec. 1. 1897 Nov. 30.	STROMEYER, JOHANN PHILIP EDMOND CHARLES	Steam Users' Association, 9 Mou Street, Manchester.
	1894 Dec. 4.	STUART, CHARLES MCDONNELL	Govt. Rys., Sydney, N.S.W.
✠	1880 Dec. 7. 1891 Feb. 3.	*STUART, ROBERT HENRY FREDERICK	F.C.G.O.A., Mendoza, Argentina.
	1904 Mar. 1.	STURGEON, JOHN	2 Woodland Grove, Chapeltow Leeds. (Sturgeon, Leeds Chape town 23.)
	1882 Mar. 7. 1894 Oct. 30.	*SUMMERS, THOMAS, D.Sc.(*Edin.*)	King, King & Co., Bombay.
	1892 Dec. 6. 1904 Mar. 29.	SUMNER, FRANK	Borough Engineer, Woolwich.
	1882 Jan. 10. 1900 Apr. 3.	*SUMNER, HERBERT GEORGE ..	King Street, Gloucester.
	1883 May 1. 1896 Mar. 24.	SUTCLIFFE, FREDERIC JOHN RAMSBOTTOM	52 Ashgrove, Bradford.
W t ✠	1877 Dec. 4. 1893 Nov. 14.	SUTCLIFFE, GEORGE WILLIAM	Whingarth, Marple, Stockport.
	1902 Feb. 4.	SWAIN, *Professor* GEORGE FILLMORE	Massachusetts Institute of Techn logy, Boston, Mass., U.S.A.
	1885 Apr. 14. 1896 May 19.	SWAN, ARCHIBALD ALEXANDER, B.Sc. (*Glas.*)	Bath Club, Dover Street, W.
	1896 Dec. 1.	SWAN, HENRY FREDERICK, C.B.	Prudhoe Hall, Prudhoe-on-Tyne.
✠	1883 Dec. 4. 1899 Nov. 28.	SWARBRICK, JOSEPH	30 St. Ann's Street, Manchester.
	1878 Dec. 3.	SWINBURN, JOHN	L.&Y.Ry., Eng.'s Office, Manchest
✠	1893 Mar. 7. 1894 Apr. 10.	SWINBURNE, JAMES	82 Victoria Street, S.W. (We minster 292.)
	1875 Jan. 12. 1883 Jan. 22.	SWINDELLS, RUPERT	22 Oxford Road, Birkdale, Sout port.
	1886 Dec. 7. 1900 Apr. 10.	*SWINDLEHURST, JOSEPH EAVES	City Engineer, Coventry.
	1877 Feb. 6. 1885 Dec. 1.	SWINDLEHURST, ROBERT HENRY	Town Hall, Bolton.
	1889 May 21. 1894 May 8.	SWINEY, JOHN HARRIS HAZLETT, B.A.I. (*Dubl.*) ..	83 Royal Avenue, Belfast.
	1890 Jan. 14. 1898 Dec. 6.	*SWINTON, ALAN ARCHIBALD CAMPBELL	66 Victoria Street, S.W. (Dunam London. Westminster 156.)
	1879 May 27.	SYKES, BENJAMIN	33 Winckley Square, Preston. (28
	1880 Feb. 3. 1886 Nov. 9.	SYKES, GEORGE HENRY, M.A. (*Dubl.*)..	Glencoe, Elmbourne Road, Tooti Common, S.W.
	1876 Feb. 1. 1887 Nov. 8.	SYMONS, BRENTON	Burwood, Warminster Road, Sou Norwood, S.E.
T t m t ✠	1883 Feb. 6. 1890 Apr. 29.	*SZLUMPER, ALFRED WEEKS ..	L. & S. W. Ry., Clapham Juncti S.W.
	1864 Dec. 6. 1867 May 21.	SZLUMPER, *Sir* JAMES WEEKS	17 Victoria Street, S.W.
	1888 Apr. 10. 1896 Jan. 21.	SZLUMPER, WILLIAM WEEKS ..	17 Victoria Street, S.W.
	1895 Jan. 8. 1903 Apr. 21.	*TABOR, EDWARD HENRY ..	Fennes, Braintree, Essex.
	1870 Mar. 1. 1876 Dec. 12.	TAIT, GEORGE HUNTER	St. Rule's, Buckhurst Road, Bexh
m ✠	1891 Dec. 1. 1897 Mar. 2.	*TAIT, WILLIAM ARCHER PORTER, B.Sc. (*Edin.*) ..	Leslie & Reid, 72A George Stre Edinburgh.
	1862 May 6.	TANNER, JOHN EDWARD, C.M.G.	Royal Thames Yacht Club, 7 All marle Street, W.
	1885 May 19.	TANNETT-WALKER, ARTHUR TANNETT	Leeds. (Tannett-Walker, Leeds. 51
	1891 Feb. 3.	TANNETT-WALKER, FREDERICK WILLIAM	Leeds. (Tannett-Walker, Leeds. 51

	Date of Election and of Transfer.	MEMBERS.	
	1897 Feb. 2.	TAPAJÓS, TORQUATO XAVIER MONTEIRO	Rua Hospicio 27, Rio de Janeiro.
	1875 Dec. 7. 1879 Nov. 4.	TATE, JOHN	Edgewood, Greencastle, Belfast.
t ✠	1887 Jan. 11. 1891 Apr. 21.	TATTON, REGINALD ARTHUR ..	44 Mosley Street, Manchester.
	1898 Dec. 6.	TAYLOR, ARTHUR	71 Edith Road, West Kensington, W.
	1881 Feb. 1. 1890 Feb. 4.	*TAYLOR, EDWARD BROUGH ..	27 Great George Street, S.W. (Waterage, London.)
	1887 Apr. 5. 1898 Feb. 8.	*TAYLOR, GOTFRED MIDGLEY ..	27 Great George Street, S.W. (Waterage, London.)
	1887 Dec. 6. 1896 Nov. 16.	*TAYLOR, HAROLD BLAKE, F.C.H.	Gwalior Residency, P.O. Central India.
	1884 May 27.	TAYLOR, HENRY ENFIELD ..	26 Newgate St., Chester. (Enfield Taylor, Chester.)
	1869 Dec. 7. 1882 Feb. 14.	TAYLOR, HERBERT ARNAND ..	4 Great Winchester Street, E.C.
	1880 Mar. 2. 1900 Jan. 30.	*TAYLOR, JAMES NAAMAN ..	Engineer's Office, G.W.Ry., Paddington, W.
	1884 Apr. 1.	TAYLOR, JOHN	6 Queen St. Place, E.C. (Bank 828.)
	1880 Dec. 7. 1899 Jan. 10.	TAYLOR, JOHN HENRY	Borough Surveyor, Barnsley.
	1902 Dec. 2.	TAYLOR, JOSEPH JEX	1 Victoria Street, S.W.
	1886 Apr. 6. 1896 Nov. 24.	*TAYLOR, WALTER	85 London Wall, E.C.
	1889 May 7. 1902 Dec. 16.	*TAYLOR, WILLIAM JAMES ..	County Surveyor, The Castle, Winchester.
	1893 Mar. 7. 1901 Dec. 11.	*TAYLOR, WILLIAM OSWALD ..	Bengal-Nagpur Railway, Calcutta.
	1886 Feb. 2. 1897 Feb. 2.	*TEMPEST, PERCY CROSLAND ..	S.E. Ry., London Bridge Station, S.E.
	1879 Mar. 4. 1894 Nov. 20.	*TERRY, STEPHEN HARDING ..	17 Victoria Street, S.W. (Crankpin, London.)
✠	1875 Apr. 6. 1883 May 22.	THELWALL, WALTER HAMPDEN	3 Tokenhouse Buildings, E.C.
	1888 Dec. 4. 1903 Apr. 7.	*THOMAS ARTHUR DREW ..	Staplake, Starcross, South Devon.
	1878 Mar. 5.	THOMAS, HUBERT	21 Surrey Street, Strand, W.C.
	1889 Dec. 3. 1902 Feb. 18.	THOMAS, ROBERT JOHN	County Surveyor, Aylesbury.
✠	1882 Feb. 7. 1887 Feb. 1.	THOMPSON, ARTHUR MOORE ..	L. & N. W. Ry., Crewe.
✠	1886 May 18. 1893 May 9.	*THOMPSON, HARRY JAMES ..	Madras Ry., Madras.
	1891 Mar. 3. 1899 Dec. 12.	THOMPSON, JAMES, B.E. (*Royal*)	P.W.D., Perth, Western Australia.
	1890 May 6.	THOMPSON, ROBERT	Metropolitan Gas Co., Melbourne, Victoria.
	1867 Feb. 5.	THOMPSON, THOMAS JEFFERSON	Greystones, co. Wicklow.
	1871 Apr. 4. 1885 Feb. 24.	THOMSON, CAMPBELL	Walton Lodge, Beulah Road, Tunbridge Wells.
	1895 Apr. 2.	THOMSON, *Professor* ELIHU ..	Lynn, Mass., U.S.
	1889 May 7.	THOMSON, GEORGE HUNTINGTON	Transportation Club, 42nd Street, New York, U.S.
	1899 Feb. 7.	*THOMSON, THOMAS	The Bungalow, Seaham Harbour, co. Durham.
	1893 May 16. 1898 Feb. 22.	*THOMSON, THOMAS FRAME ..	Winchester House, Old Broad Street, E.C.
	1880 Dec. 7. 1884 Feb. 26.	THOMSON, WILLIAM	Ronda, Spain.
	1900 Jan. 9.	THORNHILL, BENSLEY	Kashmir Ry., Srinagar, India.
	1870 May 3.	THORNHILL, EDWARD BAYLIES	80 Avenue Road, N.W.

	Date of Election and of Transfer.	MEMBERS.	
	1889 Apr. 2.	THORNHILL, JOSEPH HELEN, M.E. (*Queen's*)	Patrick's Hill, Cork.
	1891 Dec. 1. 1904 Feb. 23.	*THORNTON, JOHN ARTHUR ...	Engineer's Office, N.E. Ry., Yor
	1882 Feb. 7. 1887 May 8.	THORNTON, JOHN MILLER ..	Govt. Rys., Uitenhage, C Colony.
W S t ✠	1873 Jan. 14. 1877 Nov. 27	THORNYCROFT, *Sir* JOHN ISAAC, LL.D. (*Glas.*), F.R.S. (*Member of Council.*)	Eyot Villa, Chiswick Mall, (Thornycroft, London. Hamm smith 6.)
	1872 May 7. 1877 Dec. 11.	*THOROWGOOD, FRANK NAPIER	H. S. King & Co., Pall Mall, S.W
✠	1890 Dec. 2.	THOW, WILLIAM	Govt. Rys., Sydney, N.S.W.
	1886 May 4. 1889 Jan. 8.	THROPP, JAMES	27 The Bail, Lincoln.
	1883 Mar. 6. 1891 Dec. 1.	THURSBY, CHARLES RADCLIFFE	Calle Reconquista 20, Buenos Ai
	1881 Dec. 6.	THURSFIELD, WILLIAM EDWIN	Gumpoldskirchen, Vienna.
	1869 Dec. 7. 1876 Apr. 4.	THWAITES, CHRISTOPHER ..	Burnell Road, Sutton, Surrey.
	1898 Apr. 5.	THWAITES, HENRY	5 Cardinal Mansions, Victo Street, S.W.
	1887 Dec. 6. 1889 Nov. 5.	THWAITES, WILLIAM, M.A. (*Melb.*)	Board of Works, Melbourne, Victo
	1898 Apr. 5.	TICKELL, CHARLES	Royal Indian Engineering Colle Staines.
	1887 Dec. 2. 1901 Apr. 2.	*TICKELL, RICHARD EUSTACE .	Colombo Drainage, Ceylon.
	1888 Feb. 7.	TILNEY, JOHN DEANE, I.S.O...	Govt. Rys., East London, C Colony.
	1891 Dec. 1. 1894 Oct. 16.	TIMME, GEORGE ADOLPHUS ..	37 Egerton Park Road, Bexhill.
	1889 Dec. 3. 1898 Nov. 29.	TIMMINS, JOSEPH	Gasworks, Wigan.
	1881 Apr. 5. 1888 May 8.	TIMMIS, ILLIUS AUGUSTUS ..	2 Great George Street, S.W.
	1877 Apr. 10. 1895 Feb. 12.	*TINGLE, HENRY JOHN	31 Old Queen St., Westminster, S. (Piezometer, London.)
	1884 May. 6. 1900 Dec. 19.	TISDALL, CHARLES JEROME, B.A. (*Dubl.*)	G. I. P. Ry., Bombay.
	1903 Mar. 3.	TODD, REGINALD ROBERT ..	54 Aberdare Gardens, N.W.
	1889 Jan. 8. 1902 Apr. 15.	TOMALIN, HERBERT FREDERICK	P.W.D., Colombo, Ceylon.
	1889 May 7.	TOMKINS, WILLIAM STEELE ..	Broughton House, near Stockbrid Hants.
	1885 Apr. 14. 1891 Nov. 9.	*TOMLINSON, SAM	Gresham House, Singapore, S.S.
	1890 Feb. 4.	*TOPP, AUGUSTUS WORTHINGTON	F. Topp, Rothwells, Little Hult Bolton.
	1884 May 6.	TOWER, BEAUCHAMP	5 Queen Anne's Gate, S.W.
	1895 Feb. 5. 1899 Nov. 28.	*TOWER, WILLIAM	Rhodesian Rys., Salisbury, Rl desia.
	1886 Mar. 2.	TRAILL, THOMAS WILLIAM ..	40 The Chase, Clapham Common, S.
	1897 Apr. 6. 1904 Feb. 16.	*TRENCH, ERNEST FREDERIC CROSBIE, M.A., B.A.I. (*Dubl.*)	Drentagh, Hollycroft Aven Hampstead, N.W.
	1874 Feb. 3. 1879 Mar. 25.	TRENCH, LOUIS, B.A. (*Cantab.*)	L. & N. W. Ry., Engineer's Offi Euston, N.W.
	1887 Dec. 6. 1892 Nov. 8.	TREBY, CHARLES ALFRED ..	Bahia Blanca and N. W. Ry., 5 Cangallo, Buenos Aires.
✠	1879 Dec. 2. 1887 May 10.	TREVITHICK, FRANCIS HENRY	14 St. Aubyn's Road, Upper N wood, S.E.
	1881 Apr. 5. 1891 May 12.	TREVITHICK, FREDERICK HARVEY	Loco. Supt., Egyptian Railwa Cairo.
	1885 May 5.	TREVITHICK, RICHARD FRANCIS	P.O. Box 35, Kobe, Japan.
	1883 Dec. 4. 1897 Dec. 21.	TREVITHICK, ROBERT LOWTHIAN	Dolvean, Melville Road, Falmouth
	1866 Mar. 6. [illegible]75 Apr. 27.	TREWBY, GEORGE CARELESS ..	Fenton House, The Grove, Ham stead Heath, N.W.

	Date of Election and of Transfer.	MEMBERS.	
	1904 Mar. 1.	Trewent, Francis James ..	43 Billiter Buildings, Billiter Street, E.C.
✠	1877 Dec. 4. 1883 Nov. 29.	Tripp, William Blomefield	Spring Grove, Isleworth.
	1893 Mar. 7. 1896 Apr. 21.	Tritton, Seymour Biscoe ..	Sir Alexander Rendel, K.C.I.E., 8 Great George Street, S.W.
Tt ✠	1883 Mar. 6. 1901 Dec. 17.	*Trotter, Alexander Pelham, B.A. (*Cantab.*)	Board of Trade, 8 Richmond Terrace, Whitehall, S.W.
	1883 Dec. 4. 1893 Nov. 16.	*Trump, John	Taiping, Perak, S.S.
	1890 Dec. 2. 1900 Dec. 19.	Tuckey, Thomas William Townsend, B.E. (*Royal*) ..	Govt. Rys., Tientsin, China.
	1891 Dec. 1. 1904 Feb. 16.	Tudhope, Alfred Dryden ..	Govt. Rys., Box 291, Cape Town, C.C.
m ✠	1885 Dec. 1. 1892 Mar. 22.	*TUDSBERY, John Henry Tudsbery, D.Sc. (*Glas.*) .. (*Secretary.*)	The Institution of Civil Engineers, Great George Street, S.W. (Institution, London. Westminster 51.)
	1885 Dec. 1. 1894 Jan. 23.	*Tuit, James Edward	32 Victoria Street, S.W.
	1881 Dec. 6. 1894 Feb. 27.	*Tulloch, Frederick Herbert	Local Government Board, S.W.
	1900 Dec. 4.	Turnbull, Walter James ..	Alexr. Izat, C.I.E., B. & N. W. Ry., Gorakhpur, India.
	1866 May 15. 1877 Jan. 16.	Turner, William Barrow ..	Ponsonby Hall, Carnforth.
	1890 May 6. 1904 Apr. 12.	Tween, Charles Nelson ..	Lee Conservancy, 12 Finsbury Circus, E.C.
	1902 Mar. 4.	Twentyman, James Robert	Farnham, Boyd & Co., Shanghai, China.
✠	1869 Dec. 7. 1879 Feb. 25.	Twigg, Robert Harkness ..	3 Elmbourne Road, Upper Tooting, S.W.
	1891 Jan. 13. 1901 Feb. 5.	*Twinberrow, John Wulstan	Long Newton Reservoir, Darlington.
	1881 Dec. 6.	Tyler, John Franklyn ..	Enfield House, Marina, Lowestoft.
	1890 May 6. 1896 Nov. 24.	*Tyndale, Walter Clifford	Horseguards, Whitehall, S.W.
	1877 Apr. 10. 1880 Mar. 16.	*Tyrrell, Arthur William Nairne	1 Victoria Street, S.W.
	1880 May 4. 1885 Dec. 8.	*Tyrrell, Lewis Gordon ..	3 Alfred Place, South Kensington, S.W.
m	1880 Dec. 7. 1897 Nov. 30.	*Tysoe, Joseph	South Metropolitan Gasworks, East Greenwich, S.E.
	1897 Mar. 2.	Uhagon y Vedia, Pedro Pascual de	Real Compañia, Asturiana, Aviles, Spain.
	1865 Dec. 5. 1876 Dec. 19.	Unwin, Howard	1 Newton Grove, Bedford Park, W.
T t S L F ✠	1867 Feb. 5. 1877 Oct. 30.	UNWIN, *Professor* William Cawthorne, B.Sc. (*Lond.*), F.R.S. (*Member of Council.*)	7 Palace Gate Mansions, Kensington, W.
	1872 Dec. 3. 1879 Nov. 11.	UPCOTT, Frederick Robert, C.S.I. (*Member of Council.*).	India Office, Whitehall, S.W.
✠	1887 Mar. 1.	Urquhart, Thomas	Delny House, Delny, Ross-shire, N.B.
	1886 Feb. 2.	Ussher, Edgeworth Richard	Dunedin, Otago, N.Z.
	1877 Mar. 6. 1886 Mar. 8.	*Valentine, Frederick ..	King Staith Square, King's Lynn.
	1874 May 5.	Valpy, Henry Valpot Francis	14 Victoria Street, S.W.
	1880 Feb. 3. 1893 May 9.	*Vaudrey, John Clough ..	71 Westfield Road, Edgbaston, Birmingham. (3539.)

	Date of Election and of Transfer.	MEMBERS.	
	1903 Apr. 21.	VAUGHAN, JOHN	Balaclava House, Dowlais.
	1892 May 3.	VAUGHAN, RICHARD WYNDHAM	Dunmore, St. Catherine's Roa Southbourne, Christchurch, Hant
	1898 Dec. 6.	VAUGHAN, WILLIAM STEAINS	Cail's Buildings, Quayside, New castle-on-Tyne.
	1894 Jan. 9. 1903 Feb. 10.	*VAUGHAN-LEE, ALEC GEORGE	Admiralty Harbour Works, Dover.
	1875 May 4.	VAVASSEUR, JOSIAH, C.B. ..	Rothbury, Blackheath Park, S.E. (Exemplar, London.)
	1890 Apr. 1.	VECCHIO, ADOLPHO JOSÉ DEL	Rua Evaristo da Veiga 9, Rio d Janeiro.
	1893 May 16. 1903 Dec. 22.	VERNON, CHARLES EDWARD ..	Dock House, 109 Leadenhall Stree E.C.
TSt ✠	1865 Dec. 5. 1871 Dec. 19.	VERNON - HARCOURT, LEVESON FRANCIS, M.A. (*Oxon.*) ..	6 Queen Anne's Gate, S.W.
	1883 Feb. 5.	VICKERS, THOMAS EDWARD ..	River Don Works, Sheffield.
	1883 Feb. 6. 1899 Nov. 28.	WADDELL, JOHN ALEXANDER LOW, B.A.Sc. Ma.E.(*McGill*)	Gibraltar Building, Kansas City Mo., U.S.
	1893 May 16. 1901 Mar. 5.	WADDINGTON, JOSHUA ARTHUR PAGET	Town Hall, Marylebone, W.
	1853 Dec. 6. 1866 Dec. 17.	WADHAM, EDWARD	Millwood, Dalton-in-Furness.
	1891 Feb. 3. 1901 Feb. 19.	*WADHAM, WALTER FRANCIS AINSLIE, M.A. (*Cantab.*) ..	Millwood, Dalton-in-Furness.
✠	1891 May 5. 1895 May 14.	WAIN, EDWARD BROWNFIELD	Norton-in-the-Moors, Stoke-on Trent.
	1897 Apr. 6. 1904 Apr. 19.	WAINWRIGHT, HARRY SMITH ..	Loco. Dept., S.E.&C. Ry., Ashfor
	1870 May 24. 1874 Mar. 10.	WAKE, HENRY HAY	River Wear Commission, Sunderlan (126.)
	1883 Dec. 4. 1901 Dec. 11.	WAKELAM, HENRY TITUS ..	County Surveyor, Guildhall, Wes minster, S.W. (Westminster, 218
	1875 Dec. 7.	WALCH, GEORGE TURNER ..	H. S. King & Co., Pall Mall, S.W.
	1860 Mar. 6. 1881 Apr. 5.	WALKER, CHARLES RITCHIE ..	Ash Lodge, Gloucester Road, Uppe Teddington.
	1877 May 29. 1894 Jan. 30.	WALKER, CHARLES ROBERT ..	25 Victoria Street, S.W.
	1886 Dec. 7.	WALKER, FRANCIS BLENNER-HASSETT	Upperton, Eldorado Road, Chel tenham.
t ✠	1889 May 7. 1896 Dec. 1.	WALKER, GEORGE BLAKE ..	Tankersley Grange, near Barnsley
	1885 Apr. 14.	WALKER, JAMES, F.R.S.E. ..	Tyne Commission, Newcastle-on Tyne. [on-Tyne
	1896 Apr. 14.	WALKER, JOHN	Robert Stephenson & Co., Newcastle
	1895 Jan. 8.	WALKER, JOHN SCARISBRICK ..	Walker Bros., Ironworks, Wigan.
	1865 May 2.	WALL, PHILIP WILLIAM	9 Duke Street, Portland Place, W.
	1881 Dec. 6. 1898 Dec. 6.	*WALLACE, JAMES	The Brake, Stravithie, Fife, N.B.
	1897 Dec. 7.	WALLACE, JOHN FINDLEY ..	Illinois Central Rlrd., Chicago, U.
	1882 Mar. 7. 1891 Nov. 3.	*WALLER, JOHN EDWARD ..	29 Great George Street, S.W. (Kin caid, London. Westminster 11
	1882 May 23. 1897 Feb. 2.	WALLIS, BERESFORD GAHAN ..	United Service Club, Simla, Punja
	1880 Jan. 13.	WALLIS, HERBERT	239 Drummond St., Montreal, Canad
	1874 Apr. 14. 1886 Nov. 2.	WALMISLEY, ARTHUR THOMAS	9 Victoria Street, S.W. (Workabl London.)
	1883 Feb. 6. 1889 Nov. 5.	WALSH, HENRY DEANE, B.A.I. (*Dubl.*)	Harbour Trust, Sydney, N.S.W.
	1894 Mar. 6. 1901 Feb. 12.	*WALTON, ALFRED HENRY ..	92 Queen's Road, Brownswood Par N.

	Date of Election and of Transfer.	MEMBERS.	
T t ✠	1876 Dec. 5.	WALTON, FREDERICK THOMAS GRANVILLE, C.I.E.	c.o. Grindlay & Co., Parliament Street, S.W.
	1867 Dec. 3. 1881 May 3.	WALTON, JAMES BIRDSALL ..	12 Little College Street, Westminster, S.W.
✠	1885 Dec. 1. 1898 Nov. 29.	*WANKLYN, FREDERIC LUMB ..	Dominion Coal Co., Montreal, Canada.
	1896 Feb. 4.	WARBRICK, JOHN JAMES	Sir John Jackson, 53 Victoria Street, S.W.
t ✠	1883 Mar. 6. 1894 May 22.	WARD, HENRY	110 Cannon Street, E.C.
	1876 May 2. 1899 Mar. 28.	WARD, HENRY THOMAS SIMPSON	Director of Irrigation, Colombo, Ceylon.
	1888 May 1. 1901 Dec. 11.	WARD, JOHN	Borough Engineer, Derby.
	1880 Jan. 13. 1882 Nov. 7.	WARD, REGINALD FOSTER ..	Fellside House, Hexham.
	1887 Dec. 6.	WARDALE, JOHN DOBSON ..	3 Walker Terrace, Gateshead-on-Tyne. (Wardale, Gateshead.)
	1885 Dec. 1.	WARDEN, HOWARD WILLIAM	Badgeworth, near Cheltenham.
	1887 Mar. 1.	WARD-SMITH, WILLIAM ..	Seacliffe, Young Park, Paignton.
	1873 Apr. 1. 1880 Feb. 17.	WARE, CHARLES EDWIN ..	18 Bedford Circus, Exeter.
	1887 Dec. 6.	WARING, CHARLES EDWARD DELANCY	2 Great Chapel St., Westminster, S.W.
t ✠	1875 Apr. 6. 1879 Feb. 18.	WARING, FRANCIS JOHN, C.M.G.	12 Dean's Yard, Westminster, S.W. (Gregory, London. Westminster 358.)
✠	1872 Dec. 3.	WARING, HENRY ROBERT ..	127 San Miguel, Palma, Mallorca.
	1877 Dec. 4. 1887 Feb. 8.	WARREN, *Professor* WILLIAM HENRY	University, Sydney, N.S.W.
✠	1875 May 4. 1885 Jan. 20.	WATSON, JAMES	Waterworks Engineer, Town Hall, Bradford.
	1901 Apr. 23.	WATTS, PHILIP (LL.D. *Glas.*), F.R.S.	Admiralty, S.W.
✠	1868 Jan. 14. 1877 May 8.	WAWN, CHARLES	Tan-y-Gareg, near Carnarvon.
	1878 Jan. 15 1892 Feb. 9	WEAVER, WILLIAM	Town Hall, Kensington, W.
	1895 Mar. 5. 1901 June 26.	WEBB, ARTHUR LEWIS, C.M.G., F.C.H.	P.W.D., Cairo, Egypt.
✠	1865 May 23. 1872 Dec. 3.	WEBB, FRANCIS WILLIAM .. (*Vice-President.*)	Chester Place, Crewe.
	1901 Mar. 5.	WEBB, HARRY HOWARD	Consolidated Gold Fields, Johannesburg, Transvaal.
	1872 Jan. 9. 1891 Dec. 1.	WEBBER, CHARLES EDMUND, *Maj.-Gen.* R.E. *ret.*, C.B. ..	17 Egerton Gardens, S.W.
	1892 Dec. 6. 1894 Nov. 27.	WEBSTER, HENRY, B.A.I. (*Dubl.*)	County Surveyor, Wexford.
	1876 Feb. 1. 1889 Jan. 29.	WEBSTER, JOHN	32 Drewton Street, Bradford.
E t ✠	1879 Feb. 4. 1886 May 11.	WEBSTER, JOHN JAMES	39 Victoria Street, S.W.
	1876 Mar. 7. 1890 Jan. 21.	WEEDON, JOHN FRANCIS ..	Govt Rys., Cape Town, C.C.
✠	1888 Dec. 4. 1894 Oct. 30.	*WEIGHTMAN, WALTER JAMES	c.o. H. S. King & Co., 65 Cornhill, E.C
	1884 Feb. 5. 1897 Nov. 30.	*WEIR, THOMAS DUNCAN, B.Sc. (*Glas.*)	2 Sciennes Road, Edinburgh.
	1881 Feb. 1.	WELBY, RICHARD FLINT ..	Ravenhurst, Cockington, Torquay.
	1904 Feb. 2.	WELCH, JOHN JOSEPH	Highfield Road, Rock Ferry, Cheshire.
	1875 May 11.	WELLESLEY, GERALD EDWARD	33 Portman Square, W.
✠	1872 May 7.	WELLS, LIONEL BURY	5 John Dalton St., Manchester.

	Date of Election and of Transfer.	MEMBERS.	
	1879 Feb. 4. 1903 Apr. 7.	WELLSTED, WILLIAM HENRY	Prince's Dock Chambers, Hull.
✠	1870 Dec. 6.	WELSH, EDWARD	
	1869 Dec. 7. 1891 May 5.	WENDEN, HENRY CHARLES EDWARD, C.I.E.	G. I. P. Ry., Victoria Terminus, Bombay.
	1866 Dec. 4.	WEST, ARTHUR ANDERSON ..	Clyst House, Theydon Bois Road, Epping.
✠	1885 Dec. 1.	WEST, HENRY HARTLEY	5 Castle Street, Liverpool. (Refer Liverpool.)
	1884 May 6.	WEST, JOHN	The Firs, Park Road, Southport.
	1872 May 14. 1879 May 27.	*WESTERN, CHARLES ROBERT ..	Broadway Chambers, Westminster, S.W. (Donbowes, London. Westminster 199.)
	1877 Apr. 10. 1896 Feb. 11.	WESTHOFEN, WILHELM	P.W.D., Cape Town, C.C.
✠	1878 Jan. 15.	WESTLAND, DAVID MONRO ..	135 George Street, Edinburgh.
	1861 May 28.	WESTMACOTT, PERCY GRAHAM BUCHANAN	Rose Mount, Sunninghill, Berks.
	1889 Feb. 5. 1891 May 5.	WESTON, EDMUND BROWNELL	Providence, Rhode Island, U.S.
	1886 Apr. 6. 1903 Dec. 22.	WHALE, GEORGE	L. & N. W. Ry., Crewe.
† ✠	1867 Dec. 3.	WHEELER, WILLIAM HENRY ..	Boston, Lincs. (Wheeler, Boston.
	1885 May 5. 1902 Apr. 15.	WHIELDON, JOHN HENRY ..	Box 2551, Johannesburg, Transvaal
	1899 Dec. 5.	WHILE, JAMES MORGAN	Haematite Steel Co., Barrow-in-Furness.
	1872 Apr. 9. 1878 Apr. 30.	WHIPHAM, ARTHUR HENRY ..	Cleveland Lodge, Leamington.
	1882 Dec. 5. 1896 May 5	WHITAKER, WILLIAM BUTLER	9 Vanbrugh Park Road West, Blackheath, S.E.
	1879 Dec. 2. 1892 Feb. 16.	WHITCOMBE, CHARLES PALMER	57 Oxford Terrace, Hyde Park, W
✠	1881 Feb. 1. 1895 May 21.	WHITE, ALFRED EDWARD ..	City Engineer, Hull.
✠	1884 Jan. 8. 1899 Jan. 17.	WHITE, ALFRED GEORGE ..	11 Queen Victoria Street, E.C.
	1893 Dec. 5. 1900 Dec. 18.	WHITE, CHARLES ARTHUR ..	c/o H. S. King & Co., Pall Mall, S.W
	1862 May 6.	WHITE, CHARLES FITZWILLIAM	
	1883 May 1. 1895 Jan. 15.	*WHITE, GEORGE GILBERT ..	P. W. Secretariat, Mount Abu, Rajputana, India.
	1875 May 11. 1885 Feb. 3.	WHITE, GUILLERMO	926 Calle Libertad, Buenos Aires.
	1870 Jan. 11.	WHITE, ROBERT	66 Belsize Park Gardens, N.W. (Brentesia, London.)
	1872 Feb. 6. 1879 Jan. 14.	WHITE, WILLIAM HENRY ..	Town Hall Buildings, Oxford.
✠	1882 Feb. 7.	WHITE, *Sir* WILLIAM HENRY, K.C.B., D.Sc. (*Cantab.*), LL.D. (*Glas.*), F.R.S. (*President.*)	Cedarcroft, Bristol Gardens, Putney Heath, S.W. (White, Cedarcroft, Roehampton. Putney 276.)
	1882 Dec. 5. 1892 Feb. 23.	*WHITEHOUSE, *Sir* GEORGE, K.C.B.	Central Argentine Buildings, Buenos Aires, Argentina.
	1885 Dec. 1. 1900 Mar. 26.	WHITELEY, JOHN JOSEPH	Binny & Co., Madras.
	1866 Apr. 10. 1874 Dec. 22.	WHITING, JAMES EDWARD, M.A. (*Cantab.*)	Dunham House, Ramsgate.
✠	1874 May 5. 1891 Dec. 8.	WHITLEY, HENRY MICHELL ..	Manor Office, Eastbourne.
	1885 May 5.	WHITTEMORE, DON JUAN ..	Milwaukee & St. Paul Ry., Chicago
	1871 Apr. 4. 1879 Dec. 23.	WHITTLE, JAMES HENRY ..	11 Hamilton Road, Ealing, W.

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Date of Election and of Transfer.	MEMBERS.	
1877 Feb. 6. 1877 Oct. 30.	WHITTY, IRWINE JOHN	24 Rokeby Avenue, Redland, Bristol
✠ 1883 May 29.	WHYTE, PETER	Dock Office, Leith. (Whyte, Docks, Leith.)
1889 Feb. 5.	WICKSTEED, JOSEPH HARTLEY	Well House Foundry, Leeds.
1892 Apr. 5.	WIGRAM, REGINALD	Allerton House, Chapel Allerton, Leeds.
1881 Jan. 11. 1890 Nov. 11.	WIKE, CHARLES FROGGATT ..	City Surveyor, Bower Spring, Sheffield.
1891 May 5.	WILCOX, ERNEST SHEPLEY ..	Wirral Railway, New Brighton, Cheshire.
1904 Jan. 12.	*WILDEBLOOD, HENRY SEDDON	c/o H. S. King & Co., 9 Pall Mall, S.W
1873 May 20. 1880 Feb. 24.	WILLCOCKS, GEORGE WALLER	4 College Hill, E.C.
1903 Jan. 13.	WILLCOCKS, JOHN	William Watson and Co., Bombay
T t ✠ 1885 Dec. 1. 1887 Apr. 19.	WILLCOCKS, *Sir* WILLIAM, K.C.M.G.	Daira Sania Co., Cairo.
1895 Mar. 5.	*WILLET, ARCHIBALD WILLIAM	L. & N. W. Ry., 9 Walton's Parade, Preston.
1891 Apr. 7.	WILLIAMS, ALFRED	Penshurst Park, Hurstville, Sydney, N.S.W.
✠ 1896 Apr. 14. 1902 Dec. 16.	WILLIAMS, CYRUS JOHN RICHARD	Lyttelton Harbour Board, Christchurch, N.Z.
✠ 1860 Feb. 7.	WILLIAMS, *Sir* EDWARD LEADER (*Member of Council.*)	The Oaks, Altrincham, Cheshire.
1879 Mar. 4.	WILLIAMS, GEORGE PHIPPS, B.A. (*Cantab.*)	Upper Riccarton, Christchurch, N.Z.
1886 Feb. 2. 1900 Dec. 19.	*WILLIAMS, GILBERT PERCY ..	14 Victoria Street, S.W.
1878 Feb. 5.	WILLIAMS, JOHN AVERY BRANTON	Lingfield Grange, Branksome Park, Bournemouth.
1855 May 22. 1861 Jan. 15.	WILLIAMS, MORGAN BRANSBY	Killay House, Swansea.
1885 Dec. 1. 1901 Feb. 16.	*WILLIAMS, MORGAN IVAN MANDERSTJERNA, M.A. (*Cantab.*)	39 Victoria Street, S.W.
1890 Dec. 2. 1898 Feb. 22.	WILLIAMS, WILLIAM HUGH ..	L. & N. W. Ry., Watford.
1897 Apr. 6. 1901 Jan. 15.	*WILLIAMSON, FRANCIS STUART	257 Broadway, New York, U.S.
1900 Apr. 3.	WILLIAMSON, ROBERT SUMMERSIDE	Cannock Wood House, Hednesford, Staffs.
1890 Apr. 1. 1902 Dec. 2.	*WILLIS, HARRY ATCHISON ..	F. C. Central Cordoba, Cordoba Argentina.
1903 Feb. 3.	WILLMOT, JOSEPH WILLIAM ..	41 Tufnell Park Road, N.
1888 Jan. 10. 1896 Dec. 22.	WILLOX, WILLIAM, M.A. (*Aberd.*)	L. B. & S. C. Ry., East Croydon.
1877 May 1. 1888 Jan. 17.	*WILMER, HORACE	G. E. Ry., Stratford.
1904 Apr. 19.	WILMS, LUDWIG HERMANN ..	Box 88, East Rand, Transvaal.
1897 Feb. 2.	WILSON, ALEXANDER BASIL ..	Maryville House, Malone, Belfast.
1889 Apr. 2. 1901 Feb. 6.	WILSON, ARTHUR PRANGLEY	353 Mansion House Chambers, E.C.
1875 Dec. 7. 1890 Mar. 25.	WILSON, ARTHUR ROSS	Binsur, Almora, N.W.P., India.
1895 Dec. 3. 1901 Feb. 12.	*WILSON, FREDERICK JAMES ..	Arbuthnot & Co., Madras.
t ✠ 1863 Jan. 13. 1872 Mar. 19.	WILSON, GEORGE	8 Disraeli Road, Ealing, W.
1886 Apr. 6. 1897 Jan. 12.	WILSON, GEORGE	Redholme, Gwendolen Avenue, Putney, S.W.
1878 Mar. 5.	WILSON, JOHN	G. E. Ry., Liverpool St., E.C. (Wilson, Eastern, London.)

	Date of Election and of Transfer.	MEMBERS.	
✠	1887 Dec. 6. 1898 Nov. 29.	WILSON, JOHN ALEXANDER ..	P. W. D., Springfield, Canterb New Zealand.
	1870 Dec. 6. 1882 Nov. 7.	WILSON, JOHN HATTON	14 Roseville St., St. Helier's, Jer
	1893 Dec. 5. 1903 Dec. 22.	WILSON, JOHN ROBERT ROBINSON	182 Chapeltown Road, Leeds.
	1877 Feb. 6. 1900 Mar. 27.	WILSON, JOSEPH WILLIAM ..	Engineering School, Crystal Pal S.E.
	1884 Feb. 5. 1895 Feb. 12.	*WILSON, MAURICE FITZGERALD	Admiralty Harbour Works, Dove
	1894 Jan. 9 1899 Jan. 10	WILSON, PEREGRINE OLIVER	c.o. F. Wilson, 7 Devonshire Squ Bishopsgate Street, E.C.
	1875 Dec. 7. 1882 May 23.	WILSON, ROBERT	7 St. Andrew's Place, Regent's P N.W.
	1876 Apr. 4. 1883 Nov. 13.	WILSON, ROBERT EDWARD ..	8 Quality Court, Chancery Lane, W
✠	1886 Dec. 7.	WILSON, WALTER STUART ..	175 Hope Street, Glasgow.
	1881 Apr. 5. 1896 Apr. 21.	WINGFIELD, CHARLES HUMPHREY	15 Bilton Road, Rugby.
	1897 Jan. 12.	WINSER, SIDNEY BEAUFOY ..	Eastwood, Hathersage, Sheffield.
	1877 May 29. 1902 Dec. 23.	WINSTANLEY, GEORGE	Crackley Hall, Kenilworth.
	1888 Dec. 4.	WISE, BERKELEY DEANE ..	Northern Counties Ry., Belfast.
	1884 Mar. 4.	WOLFE, JOHN EDWARD	24 Belsize Crescent, Hampste N.W.
	1889 Dec. 3. 1898 Nov. 29.	WOLFF, WILLIAM HENRY ..	B. B. & C. I. Ry., Bombay.
	1881 May 31. 1899 Feb. 28.	*WOLLEY-DOD, FRANCIS, F.C.H.	139 Holland Road, W.
	1883 Feb. 6. 1902 Dec. 2.	*WOOD, ARTHUR PRESCOTT ..	Waterworks Shanghai, China.
	1903 Jan. 13.	WOOD, ERNEST SEYMOUR ..	5 Fairlie Place, Calcutta.
	1868 May 5.	WOOD, JOHN	18 Bank Street, Carlisle.
✠	1884 Feb. 5. 1900 Dec. 19.	WOOD, JOHN MACKWORTH. ..	New River Office, Clerkenwell, E
	1892 Dec. 6.	WOOD, JOHN THOMAS	3 Cook Street, Liverpool.
	1880 Feb. 3.	WOOD, *Sir* LINDSAY, *Bart.* ..	Southill, Chester-le-Street.
	1892 Apr. 5.	WOOD, WALTER EDMUND ..	4 Teresa Terrace, Coatham, Red
✠	1872 Dec. 3. 1877 Oct. 30.	WOODALL, CORBET	9 Bridge Street, Westminster, S. (Westminster 160.)
	1886 Mar. 2.	WOODALL, HENRY	7 South Parade, Llandudno.
	1896 Feb. 4. 1903 Dec. 22.	WOODALL, HENRY	9 Bridge Street, Westminster, S. (Westminster 160.)
	1891 Mar. 3.	WOODCOCK, WILLIAM HUGH ..	2 Great George Street, S.W.
	1866 Dec. 4. 1873 May 20.	WOODS, EDWARD HENRY ..	110 Cannon Street, E C. (Fund London.)
	1881 Dec. 6. 1899 Apr. 18.	*WOODS, RICHARD JOHN, M.E. (*Royal*), F.C.H.	Royal Indian Engineering Colle Staines.
m ✠	1892 Feb. 2. 1899 Dec. 12.	*WORDINGHAM, CHARLES HENRY	Aubrey House, Kew Road, Ri mond, Surrey.
	1884 Mar. 4.	WORSDELL, THOMAS WILLIAM	Stonycroft, Arnside, Carnforth.
	1886 Feb. 2. 1898 Nov. 29.	WORSDELL, WILSON..	N. E. Ry., Gateshead-on-Tyne.
t ✠	1881 Feb. 1. 1893 Nov. 14.	WORTH, JOHN EDWARD	County Council, Spring Garde S.W.
	1839 Apr. 23. 1861 Jan. 8.	WORTHINGTON, SAMUEL BARTON	Mill Bank, Bowdon, Cheshire.
✠	1880 Jan. 13. 1884 May 27.	*WORTHINGTON, WILLIAM BARTON, B.Sc. (*Lond.*)	Chief Engineer, L. & Y. R Manchester.
T t ✠	1870 Jan. 11.	WRAGGE, EDMUND	4 Marlborough Hill, St. Joh Wood, N.W.

Date of Election and of Transfer.	MEMBERS.	
1884 Mar. 4.	WRIGHT, JAMES WALKER ..	Fairview, De Pary's Avenue, Bedford.
1875 Mar. 2.	WRIGHT, JOHN	5 Queen's Park, Paignton, S. Devon.
1885 Apr. 14.	WRIGHT, *Hon.* JOHN ARTHUR	Government Resident, Albany, Western Australia.
1888 Feb. 7. 1901 Jan. 15.	WRIGHT, JOHN JAMES	Ivanhoe, Old Palace Gardens, Weybridge.
1884 Mar. 4.	WRIGHT, WILLIAM	Ashridge House, Spalding, Lincs.
1859 Jan. 11. 1869 Dec. 7.	WRIGHT, WILLIAM BARTON ..	c.o. Constitutional Club, Northumberland Avenue, W.C.
C ✠ 1869 Dec. 7. 1877 May 29.	WRIGHTSON, *Sir* THOMAS, *Bart.*, M.P.	5 Victoria Street, S.W.
1895 Apr. 2.	WRIGHTSON, WALSH, C.M.G. ..	Port of Spain, Trinidad.
1888 Feb. 7. 1900 Apr. 3.	*WYNNE-EDWARDS, HUGH COPNER	Sir John Jackson, Simons Town, South Africa.
1904 Apr. 19.	WYNNE, TREVREDYN RASHLEIGH	132 Gresham House, Old Broad Street, E.C.
1881 May 3. 1901 Dec. 11.	WYRILL, RALPH HENRY	Guildhall, Swansea.
1879 Mar. 4. 1898 Nov. 29.	YABBICOM, THOMAS HENRY ..	City Engineer, Bristol.
✠ 1869 Dec. 7. 1879 Nov. 4.	YARROW, ALFRED FERNANDEZ (*Member of Council.*)	Isle of Dogs, Poplar, E. (Yarrow, London. Eastern 114.)
1876 May 2.	YOCKNEY, SYDNEY WILLIAM ..	53 Victoria Street, S.W. (Yockney, London. 53 Victoria.)
✠ 1872 Apr. 9.	YOUNG, EDWARD WILLIAM ..	Rouwkoop, Rondebosch, C.C.
1865 Apr. 4. 1884 Dec. 23.	YOUNG, JAMES	Salroyd, Thornlaw Road, West Norwood, S.E.
1886 May 4.	YOUNG, JAMES	c.o. Grindlay & Co., Parliament St., [S.W.
1876 Dec. 5. 1884 Jan. 8.	YOURDI, GEORGE NICHOLAS, B.A.I. (*Dubl.*)	Cwm Elan, Rhayader, Radnorshire.
1884 Mar. 4. 1896 Nov. 16.	ZACHARIASEN, LARS SEVERIN ..	9 Bridge Street, Westminster, S.W. (Zachariasen, London.)
1887 May 24.	ZEAL, *Sir* WILLIAM AUSTIN, K.C.M.G.	5 St. James's Buildings, William Street, Melbourne, Victoria.
1895 May 21.	ZIFFER, EMANUEL ALOIS ..	I Giselastrasse 9, Vienna.

Total number of Members .. .. 2,177.

ASSOCIATE MEMBERS.

[Assoc. M. Inst. C.E.]

N.B. *Those elected prior to the 2nd of December,* 1878, *have been transferr[ed] into this class by the Council.*

Date of Election.	ASSOCIATE MEMBERS.	
1880 May 4.	Abbey, Joe Burman	34a New Street, Huddersfield.
1898 May 2.	Abbot, Frederick William	620 Chestnut Street, St. Lo[uis], Mo., U.S.
1891 Dec. 1.	*Abbott, George Herbert ..	Waterworks Office, Southport.
1891 Dec. 1.	*Abbott, James Hartley ..	Aldercliffe, Haverbreaks, Lanca[ster]
1899 Apr. 11.	Abbott, Sydney Harry ..	Municipal Buildings, Johan[nes]burg, Transvaal.
1880 Mar. 2.	*Abercrombie, Francis	23 Upper Wimpole Street, W.
1902 Apr. 8.	*Acfield, Joshua Edward ..	City Engineer's Office, Leeds.
1877 Feb. 6.	Ackermann, Adolphus William	Elm Cottage, Sidmouth.
1892 Dec. 6.	*Ackermann, Alfred Seabold Eli	47 Victoria Street, S.W. (P[ost] Telephone—Victoria 244.)
1895 Dec. 3.	Ackland, Charles George Heber	Catteral House, Chestnut Aven[ue], Hampton-on-Thames.
1897 Mar. 2.	Ackland, Thomas John Henry	St. Michael's, Holmes Grove Ro[ad], Westbury-on-Trym.
1877 Dec. 4.	*Acland, Lawford Maclean ..	P.W.D., Giant's Tank, Man[nar], Ceylon.
1902 Dec. 2.	Acocks, Herbert Francis ..	Coode & Matthews, 9 Victoria Str[eet], S.W.
1889 Feb. 5.	*à Court, Sidney	39 Victoria Street, S.W. (Toga[t] London.)
1897 Mar. 2.	*Acton, Edward Vincent ..	Water & Sewerage Dept., Port [of] Spain, Trinidad.
1894 Dec. 4.	Acton, William Walter ..	Kwala Kangsar, Perak, S.S.
1894 May 22.	Adair, Gerald Arthur, B.A.I. (*Dubl.*)	65 Lower Mount Street, Dublin.
1887 Mar. 1.	*Adam, James, F.C.H.	King, King & Co., Bombay.
1900 Jan. 9.	Adam, Matthew Atkinson, B.Sc. (*Glas.*)	29a Abbey Road, N.W.
1891 Dec. 1.	*Adam, Robert	Harbour Works, Salina Cr[uz], Oaxaca, Mexico.
1879 Feb. 4.	Adames, Cornelius George ..	Avondale, London Rd., Portsmou[th]
1893 Apr. 11.	Adams, Alexander	P.W.D., Bombala, New South Wal[es]
1903 Jan. 13.	*Adams, Bertram Keith ..	L. & Y. Ry., Crofton, Wakefield.
1894 May 1.	Adams, Burnet	Surveyor-General, Orange Ri[ver] Colony.
m 1899 Jan. 10.	*Adams, Henry Charles. ..	37 Waterloo Street, Birmingham.
1900 Feb. 6.	*Adams, Henry Regnier Campbell	56 Dunchurch Road, Rugby.
1900 Dec. 4.	Adams, Samuel Henry	Adams-Hydraulics, York.
1883 Jan. 9.	*Adams, Thomas	Engineer's Office, North Staffs. Ra[il]way, Stoke-on-Trent.
1901 Mar. 5.	Adams, William Chatterton, B.A.I. (*Dubl.*)	Polytechnic School of Engineerin[g], Ghizeh, Cairo.
1887 May 3.	Adamson, Michael	16 Stopford Road, Plaistow, E.
1889 Dec. 3.	*Addis, Frederick Henry ..	Grindlay, Groom & Co., Bombay.
1901 Dec. 3.	*Addis, Robert Bawn, F.C.H.	Grindlay, Groom & Co., Bombay.
✠ 1880 Dec. 7.	*Addison, Percy Leonard ..	Park House, Bigrigg, Cumberland

	Date of Election.	ASSOCIATE MEMBERS.	
	1898 Dec. 6.	*ADLER, HENRY GEORGE VERGOTTINI	c.o. Mellor, Smith & May, 1 Moorgate Place, E.C.
	1895 May 21.	AGABEG, FRANK JOSEPH	Apcar & Co., Sitarampore, Bengal.
	1897 Feb. 2.	AHLERS, RUDOLPH OSWALD	Dharwar Goldfields, Gadag P.O., Bombay.
	1890 Feb. 4.	AINSWORTH, ALFRED EDWARD	Midland Ry., 11 Queen's Road, Nottingham.
✠	1899 Mar. 7.	AITCHISON, GOWRIE COLQUHOUN	Glynperis, Llanberis, N. Wales.
	1901 Dec. 3.	AITKEN, THOMAS MARTIN, B.Sc. (*Glas.*)	126 Greenwich Road, S.E.
	1883 May 29.	*ALBRIGHT, JOHN FRANCIS	96 Elm Park Gardens, S.W. (Kensington 652.)
	1892 Dec. 6.	*ALBUQUERQUE-MARANHAÕ, AFFONSO DE OLIVEIRA DE	22 Rua do Commercio, Natal, Rio Grande do Norte, Brazil.
	1902 Apr. 8.	ALCOCK, ARTHUR HENRY	11 Springfield Place, Leeds.
	1899 Dec. 5.	*ALDIS, BASIL STEADMAN	43 Alkham Road, Stoke Newington, N.
	1883 Mar. 6.	*ALDRIDGE, JAMES GEORGE WILLCOX	9 Victoria Street, S.W.
	1894 May 22.	ALEXANDER, EDWARD SEYMOUR	South Indian Ry., Trichinopoly, India.
	1904 Mar. 1.	*ALEXANDER, JAMES	Engineers' Office, N.E.R., York.
	1894 Dec. 4.	ALEXANDER, JOHN HENRY	Grindlay, Groom & Co., Bombay.
	1904 Apr. 12.	ALEXANDER, JOSEPH GEORGE	167 Grosvenor Road, S.W.
	1904 Feb. 2.	*ALEXANDER, ROBERT DONALD THAIN	33 Skerton Road, Old Trafford, Manchester.
	1892 May 3.	*ALEXANDER, WILLIAM	7 Burlington Gardens, Acton, W.
	1895 Dec. 3.	*ALEXANDER, WILLIAM	Caledonian Ry., Buchanan Street Station, Glasgow.
	1892 Feb. 2.	*ALFORD, JOHN SIDNEY	G. Chatterton, 6 The Sanctuary, Westminster, S.W.
	1889 Dec. 3.	*ALLAN, JOHN FREDERICK	Apartado 990, Mexico.
	1878 May 7.	ALLEN, ALFRED	47 Victoria Street, S.W. (Westminster 402.)
	1898 Mar. 1.	ALLEN, FRANCIS WILLIAM	Boro' Surveyor's Office, Leicester.
	1883 Feb. 6.	ALLEN, GEORGE THOMAS	148 Brockley Road, Brockley, S.E.
	1896 Mar. 3.	*ALLEN, GORDON	54 Kenilworth Avenue, Wimbledon, S.W.
	1903 Jan. 13.	*ALLEN, HAROLD GWYNNE, B.A. (*Cantab.*)	Queen's Works, Bedford.
	1893 Dec. 5.	ALLEN, MARCUS	Oakdene, Knutsford, Cheshire.
M ✠	1881 Apr. 5.	*ALLEN, PERCY RUSKIN	Ferncliffe, Higher Runcorn, Cheshire.
	1898 Feb. 1.	ALLEN, RAYMOND CECIL	Chief Surveyor, Uganda, East Africa.
	1892 May 24.	ALLEN, RICHARD WILLIAM	Queen's Works, Bedford.
	1900 Feb. 6.	ALLEN, SIDNEY	G. C. Ry., Guide Bridge, Manchester.
	1885 Dec. 1.	ALLEN, WILLIAM MILWARD	199 High St., Chorlton-on-Medlock, Manchester.
	1885 Dec. 1.	*ALLIMAN, FRANÇOIS ALBERT LOUIS	2nd Line 23, Vassiljewskij Ostrov, St. Petersburg.
	1897 Feb. 2.	ALLISON, HARRY PIGOTT	F. & C. Osler, Calcutta.
	1893 Dec. 5.	ALLISON, JOHN LOGIE	Ross & Holgate, North British & Mercantile Building, St. François Xavier Street, Montreal, Canada.
m	1895 Dec. 3.	*ALLOTT, HENRY NEWMARCH	46 Brown Street, Manchester.
	1891 Jan. 13.	*ALLPORT, DOUGLAS, Jun.	6 Newton Grove, Chiswick, W.
	1904 Apr. 12.	ALLSOPP, JOHN WILLIAM KIDSTON	"Holywell," Madeley Road, Ealing.
	1894 Dec. 4.	*ALLUM, FREDERIC WARNER	G. Dixie, Roorkee, N.W.P., India.
	1897 Jan. 12.	AMAN, FREDERICK THEODOR	City Engineer's Office, Liverpool.
	1892 Mar. 1.	AMES, ERNEST FITZROY	46 Green Street, Park Lane, W.
	1885 Apr. 14.	AMOR, JUSTIN VICTOR WILFRID	5 South Parade, Bedford Park, W.

Date of Election.		ASSOCIATE MEMBERS.	
	1893 Mar. 7.	*Amphlett, Edward Albin, B.E. (*Sydney*)	Harbour Trust, Sydney, N.S.W
	1890 May 6.	Anderson, Arthur Robert ..	S.M. Ry., Dharwar, Bombay.
	1900 Feb. 6.	*Anderson, Athol Lancelot	Admiralty Breakwater Office Elmo, Malta.
✠	1899 Jan. 10.	Anderson, Charles William	Harbour Works, Penang, S.S.
C ✠	1883 Dec. 4.	*Anderson, Edward William	Leaney, Warwick Road, Soli Birmingham.
	1883 Dec. 4.	Anderson, George Gray ..	North-West Irrigation Co., L bridge, Alberta, da.
	1892 Mar. 1.	Anderson, George William	Gasworks, Whyteleafe, Surrey.
	1885 May 19.	*Anderson, Herbert William	Fairfield, Broom Road, Tedding (Kingston 186.)
	1889 May 7.	Anderson, James	Box 191, Germiston, Transvaal
	1881 Apr. 5.	Anderson, John	160 High Street, Montrose.
	1894 Dec. 4.	*Anderson, John Reid	London Sanitary Protection As 13 Charles St., St. James's, S
	1897 Mar. 2.	Anderson, John Wemyss ..	University College, Liverpool.
	1890 Dec. 2.	Anderson, Joshua Thomas Noble, B.E. (*Royal*)	Drainage Board, Dunedin, N.Z.
	1893 Jan. 10.	*Anderson, Piercie Severn ..	Dredging Co., Cairo.
	1889 Dec. 3.	*Anderson, Robert Bruce ..	5 Westminster Chambers, Vict Street, S.W.
	1897 Mar. 2.	*Anderson, Robert Hay ..	Apartado 866, Mexico City.
	1887 Feb. 1.	*Anderson, Robert Ogilvie Newton, B.A.I. (*Dubl.*) ..	Bagar Serai, Perak, S.S.
	1881 May 3.	Anderson, Robert Sanders..	County Surveyor, Peebles, N.B.
	1884 Dec. 2.	Anderson, Thomas..	58 South Woodside Road, Glasg
	1902 Dec. 2.	Anderson, Tom Scott	8 Southbourne Road, Sheffield.
	1896 Dec. 1.	Anderson, Walter Vickerstaff	City Surveyor, Winchester.
	1904 Apr. 12.	Anderson, William Ferguson	Caledonian Railway, Engine Office, 3 Germiston Street, Glasg
	1875 May 11.	André, George Guillaume..	Gunpowder Mills, Tonbridge.
	1891 Dec. 1.	Andreoni, Luis	Central Uruguay Ry., Monte Vid Uruguay.
	1894 Dec. 4.	Andrews, George Samuel Burt	Box 1049, Johannesburg, Transv
	1885 Apr. 14.	Andrews, Joseph Devonport Finney	2 Park Avenue, East Sheen.
	1903 Apr. 7.	Andrews, Leonard	Key Engineering Co., 14 Coll Land, St. Mary St., Mancheste
	1889 Dec. 3.	Andrews, Samuel George Thornton	Cefn Eithen, Swansea.
	1888 Dec. 4.	Andrews, William Wallace	Port Darwin, N.T., South Austra
	1898 Apr. 5.	Angel, Robert John	Town Hall, Spa Road, Bermonds S.E.
	1883 Mar. 6.	Angell, John Alexander ..	District Council, Beckenham, S.
	1861 Dec. 3.	Anley, James Lempriere ..	Oakley, Cheltenham.
	1896 Dec. 1.	Annan, William Craig ..	Gorakhpur, N.W.P., India.
	1875 Dec. 7.	Anson, Frederick Henry, M.A. (*Oxon.*)..	28 Victoria Street, S.W.
	1892 Feb. 2.	*Anthony, Albert Evershed	35 East Street, Brighton.
	1881 Apr. 5.	Antill, Benjamin Hillier ..	12 Queen Anne's Gate, S.W.
	1898 Apr. 5.	*Anzorena, Jacinto	Mendoza, Argentina.
m ✠	1890 Apr. 1.	*Appleby, Percy Vavasseur..	London Engine Works, Leicester.
t ✠	1901 Mar. 5.	Appleyard, Rollo	80 St. Mary's Mansions, Paddingto W.
	1897 Apr. 6.	Arbuthnott, Donald Stewart	9 Clarendon Place, Stirling.
	1890 May 20.	Archer, Oakeley	Seremban, Malay States.
	1883 May 1.	Argenti, Eduardo..	Calle de Alarcon 1, Madrid.
	1891 Feb. 3.	Armer, James	Birch & Co., 3 London Wall Buil ings, E.C.

Date of Election.	ASSOCIATE MEMBERS.	
1882 May 23.	ARMISTEAD, RICHARD	8 Charles Street, Bradford.
1890 Apr. 1.	ARMITAGE, CHARLES	Gasworks, Lancaster.
1893 Feb. 7.	*ARMITAGE, FREDERICK RHODES, B.A. (*Cantab.*)	Noan, Thurles, co. Tipperary.
1894 Feb. 6.	ARMSTRONG, CHARLES FREDERICK	Egyptian Dredging Co., Cairo.
1898 Dec. 6.	ARMSTRONG, DAVID WILLIAMS	Bridges Branch, P.W.D., Sydney, N.S.W.
1884 Dec. 2.	ARMSTRONG, LAWRENCE HENNESSEY CLUBBY	Holmwood, Happy Valley, Mussoorie, India.
1897 Apr. 6.	ARMSTRONG, SAMUEL GEORGE	Box 2139, Johannesburg, Transvaal.
1891 Dec. 1.	ARNALL, THOMAS WILLIAM ..	City Surveyor's Office, Birmingham.
1878 Feb. 5.	ARNEIL, JAMES ABRAM	57 Belmont Road, Southampton.
1904 Apr. 19.	ARNEY, ARTHUR EDWARD ..	P.W.D., Perth, Western Australia.
✠ 1899 Apr. 11.	*ARNOLD, FRANK WILLIAM ..	42 Summerfield Crescent, Birmingham.
1890 Dec. 2.	ARNOLD, THOMAS	19 John Street, Llanelly.
1891 Dec. 1.	*ARNOT, ARTHUR JAMES	83 Pitt Street, Sydney, N.S.W.
1902 Dec. 2.	ARNOTT, HENRY DUDLEY ..	171 High Street, Gorleston-on-Sea.
1891 May 12.	AROCENA, CARLOS ALBERTO ..	Calle de Piedras 163, Monte Video.
1881 Feb. 1.	ARROW, JAMES THOMAS	Mines Water Supply, Perth, Western Australia.
1876 Apr. 4.	*ARTEAGA, RODOLFO DE	72 Calle Buenos Ayres, Monte Video.
m 1902 Apr. 8.	*ARTER, ARTHUR MARSHALL ..	60 Upper Mall, Hammersmith, W.
1904 Jan. 12.	*ARTHUR, ALLAN	192A St. Vincent Street, Glasgow.
✠ 1881 Dec. 6.	ARTINGSTALL, SAMUEL GEORGE	13 S. Hamilton Avenue, Chicago, U.S.
1874 Apr. 14.	ASHBURY, THOMAS	17 St. Ann's Square, Manchester.
✠ 1885 Apr. 14.	*ASHCROFT, ANDREW GEORGE ..	1 Gainsborough Rd., Bedford Park, W.
1897 Feb. 2.	ASHCROFT, EDGAR ARTHUR ..	82 Victoria Street, S.W.
1894 Feb. 6.	ASHENDEN, PERCY	Town Hall, Rondebosch, Cape Town, C.C.
1903 Feb. 3.	*ASHFORTH, GEORGE ERNEST, M.Sc. (*Victoria*)	Thomas Wrigley, Contractor, Orrell, Lancs.
✠ 1873 May 6.	*ASHHURST, FRANCIS HENRY ..	Bhim Tal, Montpelier Rd., Ealing, W.
1899 Feb. 7.	*ASHLEY, HERBERT	Waterworks Company, Commercial Road, Portsmouth.
1886 Apr. 6.	*ASHPITEL, FRANCIS WILLIAM ..	Parry & Co., Madras.
1890 Feb. 4.	ASHWELL, HARRY	South View, Doncaster Road, Agbrigg, Wakefield.
1893 May 16.	*ASHWORTH, ARTHUR ALAN, M.A. (*Cantab.*)	Engineer's Office, Govt. Rys., Cape Town, C.C.
1895 Dec. 3.	*ASKWITH, JAMES EDGAR ..	Waterworks, Consett, co. Durham.
1892 Jan. 12.	*ASLETT, ALFRED HENRY ..	Engineer's Dept., E.I. Ry., Calcutta.
1890 Dec. 2.	ATHIM, SAMUEL	P.W.D., Barielly, India.
1886 Dec. 7.	ATKINS, ALFRED	Wanganui, N.Z.
1885 Mar. 3.	ATKINSON, ALFRED	Brigg, Lincs.
t ✠ 1891 Feb. 3.	*ATKINSON, CLAUDE WILLIAM ..	31 Manor Road, Beckenham.
1885 Feb. 3.	*ATKINSON, JOHN	Boro' Surveyor, Stockport.
m ✠ 1888 Dec. 4.	*ATKINSON, LLEWELYN BIRCHALL	30 Veronica Road, Upper Tooting, S.W.
1880 Dec. 7.	*ATKINSON, ROBERT PHILIP ..	c/o H. S. King & Co., Pall Mall, S.W.
1902 Apr. 8.	ATKINSON, WILLIAM LOWE ..	17 Cranston Road, Forest Hill, S.E.
1894 Jan. 9.	*ATLEY, GEORGE WILLIAM PERCY	Eng.'s Office, G.C. Ry., Manchester.
1888 Dec. 4.	ATTARD, WALTER	41 Strada Britannica Vittoriosa, Malta.
✠ 1878 Feb. 5.	ATTWOOD, GEORGE	13 Sise Lane, Queen Victoria Street, E.C. (Wolverly, London. Bank 5897.)
1891 Mar. 3.	AUDEN, ARTHUR CHARLES ..	30 Ancaster Drive, Anniesland, Glasgow.
1884 Dec. 2.	AUSTEN, GEORGE IDEN	Box 536, Nyack, N.Y., U.S.
m 1904 Jan. 12.	*AUSTEN, HAROLD CHOLMLEY MANSFIELD	Canon Marsh Works, Bristol.
1888 Mar. 6.	*AUSTIN, ALBERT ERNEST ..	Harbour Board, Timaru, N. Zealand.
1873 Dec. 2.	*AUSTIN, EDWARD ROBERT ..	Strangeways Ironworks, Manchester.

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	Date of Election.	ASSOCIATE MEMBERS.	
	1896 May 19.	*AVELING, THOMAS CLIFFORD ..	Central House, New Street, [Bir]mingham.
	1882 May 23.	AVELING, THOMAS LAKE ..	Boley Hill House, Rochester.
	1891 Dec. 1.	AYRES, THOMAS LAMBERT ..	Post Office, Durban, Natal.
✠	1879 Feb. 4.	AYRTON, *Professor* WILLIAM EDWARD, F.R.S...	Central Technical College, E[x]hibition Road, S.W.
✠	1885 Apr. 14.	AYTOUN, ROBERT	34 Cranbourne Terrace, Stock[ton]-on-Tees.
	1894 Jan. 9.	*BAETIE, JOHN TAYLOR	180 Hope Street, Glasgow.
	1887 Dec. 6.	*BACH, FREDERICK WILLIAM ..	c.o. H. Bach, 18 Coleridge R[oad], Crouch End, N.
	1896 May 5.	BACON, ARTHUR DRAX	Box 98, Johannesburg, Transvaal.
	1897 Dec. 7.	*BADCOCK, HUGH DANIEL, M.A. (*Oxon.*)..	Box 440, Pretoria, Transvaal.
	1892 Dec. 6.	*BADER, FREDERICK ROBERT ..	P.W.D., Sukkur, Sind, India.
	1888 Mar. 6.	*BAGGS, EDWIN	3 Walcot Parade, Bath.
	1892 Dec. 6.	*BAGOT, LEWIS BROWN	R.E. Office, Victoria Barracks, [...]
	1886 Apr. 6	*BAGSHAWE, FREDERICK THEODORE	Room 14, 142 Princess Str[eet], Winnipeg, Canada.
	1887 May 24.	BAILES, WALTER HENRY ..	L. B. & S. C. Ry., London Bridge, S[.E.]
	1894 Mar. 6.	*BAILEY, ARTHUR STOWEY ..	Loco. Dept., E.I. Ry., Jamalpur, Ind[ia].
	1901 Apr. 2.	*BAILEY, JAMES HENRY	Engineer's Office, G. N. R[y.], King's Cross, N.
	1892 Apr. 5.	*BAILEY, STANLEY CLAUDE ..	The Laurels, Banstead Road, Ew[ell].
	1875 Dec. 7.	BAILEY, WILFRED	3 Tisbury Road, Hove.
	1889 Mar. 5.	*BAILLIE, JAMES PICTON	Engineering Co., Cardigan.
	1877 Feb. 6.	BAIN, THOMAS CHARLES JOHN	Woodside, Rondebosch, Cape To[wn].
	1887 Dec. 6.	BAIRD, FRANK OSBORNE	39 Portland Road, Hove, Brighton.
	1881 Dec. 6.	*BAKER, CHARLES JOHN SEYMOUR	47 Redcliffe Square, S.W.
	1889 Jan. 8.	*BAKER, EARNEST WHEATSTONE	Lott and Walne, Dorchester.
	1904 Jan. 12.	*BAKER, ERIC SAMUEL SANCROFT, B.A. (*Cantab.*) ..	13 Wentworth Place, Newcastle-[on]-Tyne.
	1900 Feb. 6.	*BAKER, FRANK, B.Sc. (*Victoria*)	22 Paget Road, Wolverhampton.
	1899 Dec. 5.	*BAKER, GEORGE ARTHUR MARSHALL	G. C. Ry., Engineer's Office, E[...] Road, Wembley.
	1901 Feb. 5.	*BAKER, REGINALD FRANCIS ..	c.o. Clode & Baker, 66 Mark La[ne], E.C.
	1894 Dec. 4.	BAKER, TOM WILLIAM, B.A. (*Cantab.*)	Broad Street House, E.C.
✠	1841 May 11. 1867 Mar. 26.	BAKER, WILLIAM LEWIS.. ..	Hargrave, St. Neots.
	1892 Dec. 6.	BALD, FRANCIS ALOYSIUS ..	Eng.'s Office, G. E. Ry., Live[rpool] Street, E[.C.]
	1897 Mar. 2.	*BALDWIN, LEONARD LUDOVIC	Melbourne St., Coalville, Leic[s].
	1901 Dec. 3.	*BALDWIN-WISEMAN, WILLIAM RALPH, M.Sc. (*Victoria*) ..	4 Brundrett's Road, Chorlton-c[um]-Hardy, Lancs.
	1894 Jan. 9.	*BALE, GEORGE ROBERT	36 Eyot Gardens, Chiswick, W.
	1904 Jan. 12.	*BALFOUR, JOHN AYLMER ..	Anuradhapura, Ceylon.
	1892 Dec. 6.	*BALL, BENJAMIN	Boro' Engineer, Nelson, Lancs.
	1895 Mar. 5.	BALL, GEORGE	Urban District Council, Bexhill.
	1899 Jan. 10.	BALL, JOHN, Ph.D. (*Zürich*)..	Survey Dept., P.W.D., Cairo.
	1899 Dec. 5.	BALL, ROBERT STEELE	189 Gleneldon Rd., Streatham, S[.W.]
	1900 Mar. 6.	*BALLANTYNE, THOMAS	11 Sandyford Place, Glasgow.
✠	1892 May 24.	*BAMFORD, CHARLES FREDERICK	c.o. H. S. King & Co., Pall Mall, S[.W.]
	1897 Mar. 2.	BAMFORD, HARRY, M.Sc. (*Victoria*)..	University, Glasgow.
	1899 Mar. 7.	BANCROFT, FRANCIS JAMES, B.Sc. (*Lond.*)	Town Hall, Hull.
	1903 Jan. 13.	BANCROFT, FREDERICK HERBERT	88 Mosley Street, Manchester.
	1891 Mar. 3.	BANDYOPADHYAY, KRISHNACHANDRA	24 Sankaripara Road, Bhowan[ipur], Calcutta.
	[1]891 Apr. 7.	BANKS, CHARLES	Oamaru, New Zealand.

	Date of Election.	ASSOCIATE MEMBERS.	
	1890 May 20.	*Banks, Walter	Council Offices, Heaton Norris, Stockport.
	1895 May 21.	Banks, William	10 Albany Road, Rochester.
	1890 Feb. 4.	Bannister, Maunsel Caswell	Cold Storage Co., 7 Mutual Buildings, Port Elizabeth, Cape Colony.
	1895 Feb. 5.	*Barber, Edward Hazeldine	District Council, Clowne, Chesterfield.
	1904 Feb. 2.	*Barbier, Jules Edmond ..	21 Corbett Road, Cardiff.
	1893 Feb. 7.	*Barham, Hugh Garratt Foster	Water Engineer, Brisbane, Queensland.
m ✠	1893 Dec. 5.	*Barker, Charles Davidson ..	231 St. Vincent Street, Glasgow.
m ✠	1901 Jan. 8.	*Barker, Harold Wood ..	17 Woodville Terrace, Bradford.
	1892 Mar. 1.	*Barker, Joseph William ..	Town Hall, Stratford, E.
	1894 Mar. 6.	*Barker, Oswald	52 Victoria Road, Swindon.
	1890 Mar. 4.	Barker, Rayner Childe, C.I.E.	c.o. Lt.-Col. Moores, 8 Redcliffe Gardens, Southsea.
	1895 Dec. 3.	Barker, Thomas	17 Woodville Terrace, Little Horton Lane, Bradford.
	1894 Dec. 4.	Barlow, Joseph Wilmot ..	South Rand Gold Corporation, Vlakfontein East, Transvaal.
	1896 Mar. 3.	Barnard, Adam Sedgwick ..	Electrical Adviser to Govt., Colombo, Ceylon.
	1891 Feb. 3.	*Barnard, Henry Cuthbert	Railway, Ipoh, Perak, S.S.
✠	1890 May 6.	*Barnard, Robert Cary Henslow	G.I.P. Railway, Bombay.
	1892 Dec. 6.	*Barnby, Reginald Clayton	St. Mary's House, York.
	1888 Dec. 4.	*Barnes, Charles Arthur Albert	Prospect House, Cape Coast Castle, West Africa.
	1896 May 5.	Barnes, John	97 Fishergate, Preston.
	1887 Dec. 6.	Barnes, Robert Samuel Wemyss	
	1892 Dec. 6.	Barnes, Sidney Walter John	19 Denmark Road, Ealing, W.
	1884 Feb. 5.	Barnett, Charles William	Logan's Buildings, Beech Street, Penang, S.S.
	1894 Dec. 4.	*Barnett, Walter George ..	Grindlay, Groom & Co., Bombay.
	1894 May 1.	Baron, Joseph Edward ..	Ry. Dept., Existing Lines Office, Perth, Western Australia.
m ✠	1898 Mar. 1.	*Barraclough, Samuel Henry, B.E. (*Sydney*)	University, Sydney, N.S.W.
	1887 Jan. 11.	Barratt, James	Box 374, Sydney, N.S.W.
	1894 Dec. 4.	*Barratt, Samuel Harry Hill	16 Exeter Rd., Brondesbury, N.W.
	1886 Dec. 7.	Barratt, Thomas Blame ..	Town Engineer, Fremantle, Western Australia.
	1891 Dec. 1.	Barrett, Ernest James ..	Town Hall, Staines.
	1886 Dec. 7.	Barrett, Sydney Russell ..	Gas Dept., Council House, Birmingham.
	1896 Jan. 14.	Barringer, Herbert	78 Gracechurch Street, E.C.
	1879 Mar. 4.	Barron, Charles	Ovington, Alresford, Hants.
	1896 May 5.	Barron, James, Jun.	Ribble Navigation, Preston.
	1872 Dec. 3.	Barron, William Adamson ..	6 Frederick Place, Clifton, Bristol.
	1892 Dec. 6.	*Barrow, Arthur Robert ..	Sidney, British Columbia.
	1889 Dec. 3.	*Barrowcliff, George Harry	Mill Street, Loughborough.
	1889 Mar. 5.	*Barry, Herbert Alfred Lucas	15 Great George Street, S.W. (Pintle London. Westminster 367.)
	1890 May 20.	Barry, William Fitz-Gerald	Co. Surveyor's Office, Monaghan.
	1895 Jan. 8.	*Bartlett, Edward Cecil ..	T. Stewart, 6 St. George's Chambers, Cape Town, C.C.
	1896 Feb. 4.	Barton, Andrew	Admiralty, 21 Northumberland Avenue, W.C.
m	1884 Feb. 5.	*Bashall, William	
	1887 Dec. 6.	*Bassett, Herbert Stanhope	Wayside, Ilminster, Somerset.
	1900 Dec. 4.	Bastow, Arthur Henry, M.A., M.C.E. (*Melb.*)	P.W.D., Travandrum, Travancore.

Date of Election.	ASSOCIATE MEMBERS.	
1886 Feb. 2.	BATCHELOR, CYRIL TALWORTH	Orton Cottage, Water Orton, W[arwickshire]. (Stannum, Birm[ing]ham.)
1894 May 22.	BATE, DOUGLAS CLAVELL ..	127 East Dulwich Grove, S.E.
1887 Feb. 1.	BATERDEN, JAMES RAE	54 Brighton Grove, Newcastl[e-on-]Tyne.
1899 Dec. 5.	BATES, WILLIAM	Electrical Engineer's Office, Cr[...] Street, Birkenhead.
1895 Dec. 3.	BATESON, HUGH	S. P. Ry., Fazilka, Punjab.
1887 Dec. 6.	*BATLEY, CHARLES JOSEPH ..	Oldham Waterworks, Pieth[orne], Rochdale.
1893 Apr. 11.	BATTERSBY, EDMUND	Great Ness House, Baschurch.
1902 Apr. 8.	BATTLE, WILLIAM AUBREY AYLMER	Kohing, Tanuggyi, Shan Sta[tes], Burma.
H ✠ 1873 Dec. 2.	BAUERMAN, HILARY	14 Cavendish Road, Balham, S.W.
1893 Dec. 5.	BAXTER, GEORGE	93 Commercial Street, Dundee.
1890 Dec. 2.	BAYLEY, GEORGE HERBERT ..	17 Cooper Street, Manchester.
1892 Feb. 2.	BAYLEY, WALTER FRANCIS ..	127 Westbourne Avenue, Hull.
1884 May 6.	*BAYLIS, PERCY	Richmond House, Panmure R[oad], Sydenham, S.E.
1892 Apr. 5.	BAYLIS, THOMAS PHILIP	Borough Surveyor, Droitwich.
1884 Dec. 2.	BAYLISS, THOMAS RICHARD ..	Belmont, Northfield, nr. Birmingh[am].
1850 Apr. 2.	BAYNES, CHARLES CHRISTOPHER CARLETON	2 South Hill Park Gardens, N.W.
1891 Apr. 7.	*BAYNES, JOSEPH HENRY ..	Maryborough, Queensland.
1900 Apr. 3.	BAZALGETTE, EDWARD, Junr.	Cherney, Arthur Road, Wimble[don] Park, S.W.
1892 Dec. 6.	*BEADLE, FRANK EDWARD ..	44 Morpeth Mansions, Victo[ria] Street, S.W.
1892 Mar. 1.	*BEAL, EDWIN JAMES	Southern Outfall, Crossness, Ke[nt].
1890 May 20.	*BEALE, BERTRAM ROBERT, B.A. (*Cantab.*)	
1888 Jan. 10.	BEALE, HENRY FITZ GERALD	Grindlay, Groom & Co., Bombay.
1874 Jan. 13.	*BEAMISH, GEORGE HORATIO TOWNSHEND	Spy Hill House, Queenstown, Co[rk].
1880 Mar. 2.	*BEAN, ALFRED WILLIAM THOMAS	47 Prince's Square, W.
1886 May 18.	BEAN, JOHN STENNITT	L. & N. W. Ry., Crewe.
1853 Dec. 6.	BEANES, EDWARD	Moatlands, Paddock Wood, Kent.
1891 Feb. 3.	*BEARBLOCK, CHARLES WILLIAM JOHN, R.N.	5 The Terrace, Dockyard, Chatha[m].
1898 Dec. 6.	BEARD, ARTHUR CHARLES ..	London County Council, Spri[ng] Gardens, S.W.
1900 Jan. 9.	BEARD, EDWIN THOMAS	4 The Crescent, Scarborough.
1903 Jan. 13.	*BEARD, SAMUEL ROBERT HARDWIDGE	Harbour Works, Colombo, Ceylon.
1883 Dec. 4.	*BEARDMORE, WILLIAM LEE ..	C. E. Newnham, 19 Eastcheap, E.C.
1899 Mar. 7.	BEATON, ANGUS JOHN	Central S. African Rys., Johann[es]burg, Transvaal.
1892 Apr. 5.	BEATTIE, GEORGE LENNOX ..	136 George Street, Edinburgh.
1898 Feb. 1.	*BEATTY, JOSEPH NICHOLSON, B.E. (*Royal*)	Naylor Brothers, Clifton, n[r.] Penrith.
1903 Apr. 7.	*BEAUMONT, EUGENE GUY EUSTON	22 Outer Temple, 222 Strand, W.[C.]
1887 Mar. 1.	*BEAUMONT, PERCY MUNRO ..	Maldon, Essex.
1891 Jan. 13.	BECHER, CHARLES FREDERICK, B.A.I. (*Dubl.*)	County Council, Spring Gardens, S.[W.]
1889 Dec. 3.	*BECHER, HARRY, B.A. (*Dubl.*)	County Council, Spring Gard[ens], S.W.
1899 Jan. 10.	BECHER, WILLIAM STEWART, B.A.I. (*Dubl.*)	Cwm Elan, Rhayader, Rads.
1893 May 16.	BECKETT, EDWARD HENRY ..	Sanctuary House, Tothill Str[eet], Westminster, S.W.
1885 Dec. 1.	*BECKETT, WILLIAM MARROW ..	33 Brazennose Street, Manchester.

Date of Election.	ASSOCIATE MEMBERS.	
1890 Mar. 4.	*BECKH, HARRY OSCAR, M.A. (*Cantab.*)	71 Palmerston Road, Rathmines, Dublin.
1872 May 7.	BECKINGSALE, EDGAR WILLIAM	Eastrop Lodge, Basingstoke.
1891 Feb. 3.	*BECKS, GEORGE ARTHUR ..	Broadway House, Westminster, S.W.
m 1886 May 4.	*BECKWITH, ARTHUR	Usk Paper Works, Crickhowell.
1879 May 6.	*BEEMAN, JOSEPH SAMUEL ..	20 Maxilla Gardens, Notting Hill, W
ı ✠ 1899 Dec. 5.	*BEER, WALTER	47 Victoria Street, S.W. (Argano, London.)
1882 Feb. 7.	*BEEVER, BERULF WATSON ..	9 Albert Square, Manchester.
1896 May 5.	BEKENN, CHARLES FREDERIC ..	Thos. Parker, Ltd., Wolverhampton.
1887 Jan. 11.	*BELCHER, HUGH WALTER, M.A. (*Oxon.*)	53 Drayton Gardens, S.W.
1891 Mar. 3.	BELFIELD, REGINALD	Westinghouse Building, Norfolk Street, Strand, W.C.
1897 Jan. 12.	BELL, ANDREW WALKER ..	Burgh Engineer, Dunfermline, N.B.
1904 Jan. 12.	BELL, ARTHUR LANGTRY, B.E., B.A. (*Royal*)	H.M. Dockyard, Malta.
1895 Dec. 3.	*BELL, ERNEST ALBERT SEYMOUR, F.C.H.	Inglisby, Shillong, Assam.
1881 Dec. 6.	*BELL, GEORGE	Boro' Surveyor's Office, Swansea.
1904 Apr. 12.	BELL, HENRY COOKE	Ardlussa, Bangor, co. Down.
1889 Jan. 8.	BELL, JOHN FERGUSON	Gas Company, Friar Gate, Derby.
1898 Dec. 6.	BELL, NORMAN MACLEOD ..	149 Elizabeth Street, Brisbane, Queensland.
1886 May 18.	*BELL, ORIENT	13 William Street, Woolwich.
1899 Apr. 11.	*BELL, WALTER HENRY	13 Uxbridge Road, Surbiton.
1897 Dec. 7.	BELLAMY, ALFRED ROWE ..	Fordsburg, Edgeley, Stockport.
1898 Jan. 11.	BELLAMY, CHARLES REVILL ..	Gas Department, Liverpool.
1883 Mar. 6.	BELLAMY, HENRY FRANKLIN ..	6A Courtenay Street, Plymouth.
1880 Apr. 6.	BELTON, WILLIAM	Gas Light Company, Shrewsbury.
1882 May 2.	BENCE-PEMBROKE, FREDERICK CHARLES	Hartland House, Bude, Cornwall.
1885 Dec. 1.	BENEST, EDWARD BENEST SHAW	Caixa 403, Rio de Janeiro.
1894 Mar. 6.	BENEST, HENRY	Telegraph Works, Silvertown, E.
1884 Feb. 5.	*BENHAM, PERCY	60 Ridgmount Gardens, W.C.
1903 Mar. 3.	*BENJAMIN, EDGAR LIONEL ..	92 Sutherland Avenue, Maida Vale, W.
1882 Apr. 4.	BENNATON, NEWTON	E.F.O.B., Cachoeira, São Paulo, Brazil.
1900 Apr. 3.	BENNETT, EDWARD LEIGH ..	c.o. Resident General, Selangor, S.S.
1892 Dec. 6.	*BENNETT, GERALD WINZAR ..	The Close, Salisbury.
1885 Apr. 14.	BENNETT, HARRY JOHN TOLER	2 Wilmer Terrace, Parsonstown, Ireland.
1889 Apr. 2.	BENNETT, JAMES BOWER ..	12 Hill Street, Edinburgh.
1875 Apr. 6.	BENNETT, JOHN	13 Drayton Gardens, Kensington, S.W.
1894 Dec. 4.	*BENNETT, LIONEL VAUGHAN, B.A.I. (*Dubl.*)	5 King's Pier, Liverpool.
1901 Apr. 2.	BENNETT, ROBERT FORBES ..	Engineer's Office, G. N. Ry., King's Cross, N.
1889 Dec. 3.	BENNETT, THOMAS	Kalk Bay Municipality, Muizenberg, Cape Colony.
1897 Feb. 2.	BENNETT, THOMAS	8 Hindes Road, Harrow.
✠ 1880 Dec. 7.	BENNETT, WILLIAM BENJAMIN GEORGE	Midland Bank Chambers, Southampton.
1885 Dec. 1.	BEN-SAUDE, JOAQUIM	Ben-Saude & Cie., Lisbon, Portugal.
1881 Dec. 6.	BENSON, CHRISTIAN	Govt. Rys., Sekondi, Gold Coast.
1886 Apr. 6.	*BENSON, DAVIS EDMONDSON ..	18 Lansdowne Rd., Southport.
✠ 1887 Dec. 6.	*BENSON, JOHN JAMES BOURNE	Executive Engineer, Ahmednagar, India.
1898 Apr. 5.	*BENSON, WILLIAM	Boro' Engineer's Office, Salford.
1898 Apr. 5.	BENTLEY, JAMES HENRY	6 Fern Street, Oldham.
t ✠ 1892 Jan. 12.	BERG, SIGVARD JOHNSON ..	Chur, Switzerland.

	Date of Election.	ASSOCIATE MEMBERS.	
	1902 Dec. 2.	BERGIN, WILLIAM MARMADUKE, B.E. (*Royal*)	Imperial Railways, Tientsin, Chi
	1901 Jan. 8.	*BERGMAN, GEORGE ERNEST, B.A. (*Cantab.*)	29 Priory Road, Kilburn, N.W.
	1894 May 22.	*BERINGER, OTTO LEOPOLD ..	Fort Jamieson, Rhodesia.
	1896 May 19.	*BERKELEY, ARTHUR MOWBRAY	The Almners, Chertsey.
	1891 Mar. 3.	BERKLEY, MICHAEL GRAHAM	King, King & Co., Bombay.
m	1897 Dec. 7.	*BERRIDGE, HAROLD	Jacobs & Davies, 128 Broadw New York, U.S.
	1896 Jan. 14	*BERRY, ROBERT ALEXANDER JOHN	c.o. Agent, Southern Mahratta R India.
	1891 Dec. 1.	BERRY, WILLIAM WALTON ..	Bridgewater Trust, Walkden, Lan
	1902 Dec. 2.	BERTHON, CLAUDE TINNE ..	49 Eastcheap, E.C.
	1891 Apr. 7.	*BERTLIN, ANTHONY	Contractor's Office, Gerrard's Cro Bucks.
	1897 Feb. 2.	BERTLIN, PERCY WALTER ..	HilseaTunnel Works,Cosham,Han
	1894 Jan. 9.	*BESSEMER,ALFREDGEORGE,Jun.	Loreto, Cottenham Park Ro Wimbledon.
	1886 May 18.	*BEST, HARRY ROBERTSON ..	47 Victoria St., S.W. (Nomiso, Lo don. 3095.)
	1888 May 15.	BESWICK, WILLIAM HENRY ..	214 Astley Street, Dukinfield.
	1880 Dec. 7.	BETTS, EDWARD PETO	Hill House, Camberley, Surrey.
	1897 Mar. 2.	*BEVAN, PHILIP JAMES	12 Little College St., Westminste S.W.
	1888 Dec. 4.	BEVERIDGE, JOHN	Metropolitan Board of Water Suppl Pitt Street, Sydney, N.S.W.
	1877 Mar. 6.	*BEYNON, GEORGE WILLIAM	G. W. Ry., Reading.
	1892 Jan. 12.	BEYNON, JOHN COWELL STARK	Box 2926, Johannesburg, Transvaa
	1886 May 18.	BHADA, NASARVANJI DORABJI	Assistant Water Engineer, Sto Building, Grant Road Statio Bombay.
	1897 Dec. 7.	BHORE, JOHN	Palace Division, Government, My sore.
	1900 Jan. 9.	BICKERDIKE, ROBERT, JUN., Ma.E. (*McGill*)	180 St. James Street, Montrea Canada.
	1894 May 1.	*BICKERSTETH, EDWARD CHARLES	Ashleigh, Crewe.
	1897 Apr. 6.	*BICKERTON, WILLIAM HENRY, JUN., B.Sc. (*Victoria*)	Midland Ry., New Works Dept Derby.
	1904 Jan. 12.	*BIDEN, FREDERICK ALAN ..	P.W.D., Hong Kong.
	1902 Jan. 14.	*BIDWELL, LEONARD SHELFORD, B.A. (*Cantab.*)	61 Bushwood Road, Kew Gardens.
	1875 Feb. 2.	BIEBER, ALBERT OTTO	Boulevard Exelmans 126, Paris.
✠	1887 Dec. 6.	BIGGART, ANDREW STEVENSON	39 Sherbrooke Avenue, Pollok shields. Glasgow.
	1900 Mar. 6.	BIGGS, ALBERT ASHLEY.. ..	King, King and Co., Bombay.
	1887 Dec. 6.	BIGLEY, THOMAS MOYLES ..	19 Castle Street, Liverpool. (Bigley Liverpool. 6472.)
	1892 Dec. 6.	*BILL, HERBERT EDWARD ..	155 Lea Road, Wolverhampton.
	1892 Mar. 1.	BILTON, HENRY JOHN INWOOD	Ry. Dept., Melbourne, Victoria.
	1903 Feb. 3.	*BINDLOSS, EDWARD ALEXANDER MORGAN	
	1888 Dec. 4.	BINET, EDWARD PHILIP.. ..	Box 102, Krugersdorp, Transvaal.
	1897 Feb. 2.	*BINGHAM, PERCY MOORE ..	P.W.D., Sataragamuwa, Ceylon.
	1900 Dec. 4.	*BINNIE, ALEXANDER THOMAS, B.A. (*Cantab.*)	77 Ladbroke Grove, Notting Hill, W.
	1903 Apr. 7.	*BINNS, ASA	Works Dept., H.M. Dockyard, Chatham.
	1896 Apr. 14.	BINNY, WILLIAM MURRAY ..	53 Victoria Street, S.W.
	1884 Feb. 5.	*BIRCH, EDWARD ROBERT, B.A.I. (*Dubl.*)	Millview, Bridgetown, co. Donegal.
	1881 Dec. 6.	BIRD, GEORGE ROWLAND ..	P.W.D., Bareilly, N.W.P., India.

Date of Election.	ASSOCIATE MEMBERS.	
1896 May 19.	*BIRD, SIDNEY JAMES	H.M. Prison, Johannesburg, Transvaal.
1883 May 29.	*BIRD, WILLIAM HENRY	Eng.'s Office, G. E. Ry., Liverpool St., E.C.
1843 Mar. 7.	BIRKBECK, GEORGE HENRY ..	31 King Henry's Rd., Hampstead, N.W.
1883 Apr. 3.	*BIRKETT, ROBERT	33 Cavendish Rd., Brondesbury, N.W.
1900 Dec. 4.	*BIRKS, LAWRENCE, B.Sc. (*Adelaide*)..	Christchurch, N.Z.
1892 Dec. 6.	BIRNIE, NORMAN	Ry. Dept., Melbourne, Victoria.
1890 Dec. 2.	*BIRT, RAYMOND JOHN	c.o. Hydraulic Engineer, P.W.D., Pretoria, Transvaal.
1901 Apr. 2.	*BISHOP, CHARLES HERBERT ..	The Gables, Egremont, Cheshire.
1904 Jan. 12.	*BISHOP, WILFRID HOCART ..	J. Bishop, St. Jacques, Guernsey.
1892 Dec. 6.	*BISS, CYRIL HOLM	Ry. Dept., Auckland, N.Z.
1899 Dec. 5.	BITTENCOURT, ANTONIO BAPTISTA RAMOS	Obras Publicas, Rua do Preiachoelo, 151, Rio de Janeiro.
1894 Feb. 6.	BLACK, GEORGE MACARTNEY CAMPBELL	Tilbhoom Tea Co., Chandkhira P.O., Karimganj, India.
1903 Jan. 13.	BLACK, JOHN FREDERICK, B.Sc. (*Glas.*)	Lagarie, Row, Dumbartonshire.
m 1901 Apr. 2.	*BLACKBURN, ALFRED BROWN ERNEST	Water Co., Maritime Buildings, Sunderland.
1901 Dec. 3.	*BLACKBURN, CHARLES BEWICKE, B.Sc. (*Victoria*)	Falcon Works, Loughborough.
1885 Apr. 14.	*BLACKBURN, CHARLES HENRY	Garrison Engineer, Rawal Pindi, India.
1883 Feb. 6.	*BLACKBURN, EDWARD HERBERT	Parliament Mansions, Victoria Street, S.W.
1902 Apr. 8.	BLACKBURN, GERALD RICKETT	Tramways Department, 15 Bridge Street, Bradford.
1890 May 6.	BLACKBURN, JOHN	Colne Valley Waterworks, Bushey.
1893 May 2.	*BLACKER, JOHN RICHARD ..	The Bungalow, Kilrane, Wexford.
1881 Dec. 6.	BLACKETT, JAMES WILLIAM ..	Box 1121, Johannesburg, Transvaal.
1883 Feb. 6.	*BLACKMORE, GEORGE FREDERICK	30 Rylett Crescent, Ravenscourt Park, W.
1895 Dec. 3.	BLACKSHAW, WALTER	P.W.D., Kuala Kangsar, Perak, S.S.
1888 Dec. 4.	BLACKSHAW, WILLIAM	Boro' Surveyor, Stafford.
1874 Apr. 14.	BLACKWELL, CHARLES	Mount Lookout, Cincinnati, Ohio, U.S.
1899 Mar. 7.	*BLAINE, FREDERICK HOWIE, B.A. (*Cantab.*)	Sir Frederick Blaine, Jetty Street, Port Elizabeth, C.C.
1889 Jan. 8.	BLAINE, ROBERT GORDON, M.E. (*Royal*)	Afton Lodge, Stanley Road, South Woodford, N.E.
1904 Jan. 12.	BLAIR, GEORGE, B.Sc. (*Glas.*)	Motor Syndicate, Underwood, Paisley.
1889 Jan. 8.	*BLAIR, GEORGE, JUN.	4 Kinnoul Place, Dowanhill, Glasgow
1878 Apr. 2.	BLAIR, JAMES MACLELLAN ..	Clutha Ironworks, Glasgow.
1890 Apr. 1.	BLAKE, GEORGE BENJAMIN ..	County Engineer, Pahiatua, Wellington, N.Z.
1897 Apr. 6.	BLAKE, GEORGE ROBERTSON ..	219 St. Vincent Street, Glasgow.
1895 May 21.	BLAKE, HENRY KYNASTON ..	79 Tierney Road, Streatham Hill, S.W.
1897 Feb. 2.	*BLAKE, RUSTAT, B.A. (*Cantab.*)	South Harrow Railway, Ealing, W.
1904 Jan. 12.	*BLAKER, WILLIAM HERBERT ..	Admiralty Harbour, Simonstown, South Africa.
1881 Feb. 1.	BLAKESLEY, JOHN HOLMES, M.A. (*Cantab.*)	55 Victoria Street, S.W.
1869 Dec. 7.	BLAXLAND, GEORGE	Gillingham House, near Chatham.
1896 Apr. 14.	BLEAZBY, ROBERT, B.A.I. (*Dubl.*)	Ry. Dept., Coolgardie, Western Australia.
1903 Apr. 7.	BLENKINSOP, MARTIN ALFRED	Borough Engineer's Office, Cardiff.
1900 Mar. 6.	*BLES, CHARLES MARCUS, M.Sc. (*Victoria*)	Palm House, Higher Broughton, Manchester.

	Date of Election.	ASSOCIATE MEMBERS.	
	1893 Dec. 5.	BLEW, ANDERSON WEBB ..	Cia. de Tierras, Vera, Santa Argentina.
	1887 May 24.	BLIZARD, JOHN HENRY	Lansdowne House, Southampton
	1886 Jan. 12.	*BLOMFIELD, VALENTINE JOHN STUART	D.P.W., Moss Vale, N.S.W.
	1887 Mar. 1.	BLUE, JOHN ALEXANDER CRAIG	Nile Reservoir Wks., Assuan, Egy
	1884 May 27.	BLUM, ALEXANDER SAMUEL ..	Postfach, Galgocz, Hungary.
	1897 Jan. 12.	BLUNDELL, JOHN CHRISTOPHER	G.W. Ry., Broadway, Worcest shire. [burg
	1891 Apr. 7.	BOATH, ROBERT	N.B. Ry., 23 Waterloo Place, Ed
	1889 Dec. 3.	BOBY, WILLIAM	Salisbury House, London Wall, E. (Buccula, London.)
	1899 Feb. 7.	BODDIE, CHARLES LITTLEBOY	County Surveyor, Londonderry.
	1893 Dec. 5.	BODE, HUBERT FRANCIS TORIANO	Ry. Construction Branch, P.W.I Sydney, N.S.W.
	1903 Apr. 7.	*BODEN, ARTHUR LIONEL ..	34 Maitland Park Villas, N.W.
	1882 Dec. 5.	BOGER, JOHN RICHARD	West Middlesex Waterworks, Ha mersmith, W.
	1899 Dec. 5.	*BOISSIÈRE, HECTOR ELIE DE, B.Sc. (*Edin.*)	Admiralty Harbour Works, Dover
T t ✠	1891 Dec. 1.	*BOLTON, REGINALD PELHAM ..	Syndicate Building, Liberty a Nassau Streets, New York, U.S
	1879 Feb. 4.	*BOND, CECIL PHILIP WILLIAM	
	1889 Dec. 3.	BOND, GEORGE CRESWELL ..	Aspley House, Nottingham.
	1891 Jan. 13.	BOND, HORACE SAMUEL	Midland Ry., Brecon.
	1891 Mar. 3.	BOND, WALTER	Town Engineer, East London, Africa.
	1898 Apr. 5.	*BONHAM-CARTER, REGINALD ..	Consulado Britannico, Linares, Spai
	1903 Apr. 7.	*BONSTOW, THOMAS LACEY ..	73 Maison Dieu Road, Dover.
	1897 Mar. 2.	*BOOTH, HUBERT CECIL	25 Victoria Street, S.W.
	1904 Jan. 12.	BOOTHBY, BASIL TANFIELD BERIDGE	Bartonfields, Canterbury.
	1902 Apr. 8.	BORRETT, CHARLES ROBERT DUDLEY	8 Castlebar Road, Ealing, W.
	1898 Dec. 6.	BOSCAWEN, PERCIVAL NOEL ..	Dockyard, Liverpool.
	1893 Mar. 7.	*BOSMAN, WALTER	P.W.D., Durban, Natal.
	1886 Dec. 7.	*BOTHAMS, ALFRED CHAMPNEY	32 Clipper Lane. Salisbury.
	1897 Mar. 2.	*BOTLEY, CHARLES FREDERIC	Guildables, Hastings. [S.W
	1896 Dec. 1.	BOTTERILL, CHARLES	St. Botolph's, Fulham Palace Road
	1892 Dec. 6.	*BOTTLE, FRANK WALKER ..	46 Charlwood Street, Pimlico, S.W
	1899 Dec. 5.	BOULDEN, FREDERICK	Technical Department, Universit College, St George's Square, Sheffield
T t ✠	1879 May 27.	BOULT, WILFRID SWANWICK ..	32 North Side, Wandsworth Common S.W.
	1904 Apr. 19.	*BOULTON, CHARLES VALENTINE	17 Wandle Road, Upper Tooting S.W.
	1884 Dec. 2.	*BOULTON, JAMES FETTES ..	Praya Reclamation Works, Hong Kong
	1888 May 15.	BOURCHIER, EDWARD HERBERT	13 Queen Anne's Gate, West minster, S.W.
	1894 Jan. 9.	BOURGOUD, AGUSTIN EMILIO	Credito Industrial Gijones, Gijon Asturias, Spain.
	1894 May 22.	BOURNE, CHARLES	Fabbrica del Gas, Milan.
	1884 Mar. 4.	*BOURNE, JAMES JOHNSTONE ..	14 Manor Park, Lee, S.E. [S.W
	1877 Dec. 4.	BOURNE, ROBERT WILLIAM ..	c.o. Miss Bourne, 18 Hereford Square
t ✠	1890 Feb. 4.	*BOURNE, THOMAS JOHNSTONE	Peking Syndicate, Tientsin, China.
	1900 Dec. 4.	*BOVEY, EDWARD PALK, JUNR., B.A.Sc. (*McGill*)	Briarfield, Torquay.
	1896 Apr. 14.	*BOWDEN, ERNEST NEWTON ..	14 Ridgefield, Manchester.
	1893 Jan. 10.	BOWDEN, FREDERICK WILLIAM	Public Offices, Grassendale, Liverpool
	1893 Apr. 11.	BOWDEN, HENRY WHITE ..	3 Amersham Road, Putney Hill S.W. (Battersea 392).

Date of Election.	ASSOCIATE MEMBERS.	
1869 Feb. 2.	BOWDEN, JOHN	Ridgefield, John Dalton Street, Manchester.
1899 Dec. 5.	BOWEN, ERNEST FRANCIS SINDERBY	Public Works Office, Barbados.
1881 Apr. 5.	BOWEN, JOHN	Borough Engineer, Reading.
1900 Dec. 4.	*BOWEN, MERVYN WILLIAM COLE, B.A.I. (*Dubl.*)	Drainage Works, Colombo, Ceylon.
1890 Dec. 2.	BOWEN-JONES, WILLIAM THOMAS	Bronala, Carnarvon.
1899 Mar. 7.	*BOWER, THOMAS BOWYER ..	51 Wynnstay Gardens, Kensington, W.
1904 Jan. 12.	BOWER, WILLIAM NELSON ..	Corn Exchange Buildings, Manchester.
✠ 1891 Dec. 1.	BOWES, ARTHUR	Town Hall, Earlestown, Lancs.
1898 Mar. 1.	BOWKER, ARTHUR FRANK ..	Seal, Sevenoaks.
1893 Mar. 7.	BOWLES, AUGUSTUS ROBERT ..	Surveyor's Office, Sandgate.
1894 May 1.	*BOWMAN, ERNEST JOHN VIVIAN	Bengal-Nagpur Ry., Adra Station. Ragundathpur P.O., Manbhum, Bengal.
1900 Dec. 4.	BOWMAN, JOHN	Post Office, Dunedin, N.Z.
1896 Apr. 14.	BOX, EDWARD	Smith's Dock Co., North Shields.
1903 Apr. 7.	*BOYAJIAN, HENRY SAMUEL ROGERS	Post Office, Calcutta.
1896 Apr. 14.	BOYD, ANDREW, B.E. (*Royal*)	48 Church St., Ballymena, Ireland.
1899 Apr. 11.	BOYD, JOHN CAMPBELL ..	3A Market Arcade, Carlisle.
1880 Dec. 7.	BOYLAN, JOHN	Imperial Chambers, Auckland, N.Z.
1902 Jan. 14.	*BOYLE, EDWARD SEYMOUR SKINNER	Hotel Tortosa, Almeira, Spain.
1895 Apr. 2.	*BOYLE, JOHN CHARTERS	The Mall, Armagh.
1898 Feb. 1.	BRACKEN, THOMAS WILSON ..	5 North Terrace, Newcastle-on-Tyne.
1898 Apr. 5.	*BRACKENBURY, CHARLES ERNEST	Continental Union Gas Co., 7 Drapers Gardens, E.C.
1893 Feb. 7.	*BRADFIELD, JOHN JOB CREW, M.E. (*Sydney*)	Roads and Bridges Dept., Sydney, N.S.W.
1889 Jan. 8.	*BRADFORD, HUGH MELLER ..	5 Sandwell Mansions, West Hampstead, N.W.
1902 Dec. 2.	BRADFORD, MARK GORDON ..	P.W.D., Kuching, Sarawak, Borneo.
1893 Feb. 7.	*BRADLEY, ARTHUR WALTER ..	Boro' Engineer, Bury, Lancs.
1895 Dec. 3.	*BRADSHAW, JOHN BARKER ..	R.E. Office, Rupert Lane Barracks, Liverpool.
1892 May 24.	*BRADY, CHARLES ROBERT ..	Adswood, Stockport.
1888 Mar. 6.	BRAGA, ANTONIO LUSTOZA PEREIRA	P.O. Box 642, Rio de Janeiro.
1900 Dec. 4.	*BRAID, GEORGE GLADMAN ..	Y.M.C.A. Club, 100 Bothwell Street, Glasgow.
1891 May 5.	BRAIN, FRANK WILLIAM THOMAS	Trafalgar House, Drybrook, Glos.
1903 Apr. 7.	BRAINE, CHARLES DIMOND HORATIO	Irrigation Dept., Pretoria, Transvaal.
1884 Dec. 2.	BRAMAH, EDWARD HENRY ..	Clonsceen, Bridge of Weir, N.B.
1883 Dec. 4.	BRAMHAM, WILLIAM	86 Bow Road, E.
1894 Dec. 4.	BRANDRAM, ANDREW GEORGE	Portsmouth Corporation, Festing Grove, Southsea.
1897 Apr. 6.	BRANFILL, BENJAMIN	26 London Rd., Neath, South Wales.
1864 May 24.	BRANFILL, JOHN ARTHUR CAPEL	25 Rosendale Rd., W. Dulwich, S.E.
1863 Jan. 13.	BRASSINGTON, JOHN WATTS ..	17 Gloucester Walk, Campden Hill, W.
1894 Dec. 4.	*BRAZIL, JOSEPH PETER	Vulcan Works, Avonside, Bristol.
1894 Dec. 4.	*BREARLEY, FREDERICK THOMAS	Pendennis, Muizenburg, Cape Colony.
1904 Jan. 12.	*BREARLEY, JOSEPH HENRY DRAPER, B.E. (*Sydney*) ..	Box 361, Dunedin, N.Z.
1880 Feb. 3.	*BREBNER, ROBERT CHARLES ..	4A St. Andrew Square, Edinburgh.
1890 Mar. 4.	*BREMNER, ALEXANDER	G.I.P. Ry., Akola, Berar, India.

	Date of Election.	ASSOCIATE MEMBERS.	
✠	1898 Dec. 6.	BREMNER, CHARLES EDWARD..	Waimate, South Canterbury, N.Z.
	1895 Dec. 3.	*BREMNER-DAVIS, WILLIAM JOSEPH	Read & Co., 5 Colston Building Malvern Link.
	1888 Dec. 4.	*BRENCHLEY, JOHN VAUGHAN	Glaneirw, Cardigan.
	1891 Dec. 1.	BRERETON, LEONARD	Govt. Rys., Maritzburg, Natal.
	1885 Apr. 14.	*BREWER, FRANK	25 Broad Street, New York, U.S.
	1901 Dec. 3.	*BREWER, ROBERT WELLESLEY ANTONY	Queen Anne's Mansions, St. James' Park, S.W.
	1883 May 1.	BREWSTER, EDWIN HENRY GEORGE..	12 Dartmouth Street, Queen Anne' Gate, S.W.
	1879 Feb. 4.	*BRICE, EDWARD ERNEST.. ..	171 Elm Park Mansions, Park Walk Chelsea, S.W.
	1886 Mar. 2.	*BRICKNELL, FREDERICK WILLIAM	City Engineer's Office, Hull.
	1897 Jan. 12.	BRIERLEY, BRANDON TALFOURD	Linthwaite, Delph, Oldham.
	1894 Dec. 4.	BRIERLEY, JOHN HENRY ..	Boro' Surv.'s Office, Richmond, S.W
✠	1877 Apr. 10.	BRIFFAULT, FREDERIC	6 Cathcart Road, Kensington, S.W.
	1884 Dec. 2.	BRIGDEN, JAMES	11 Clifton Terrace, Brighton. (37.
	1891 Dec. 1.	BRIGGS, CHARLES	Howden, East Yorks. [S.W
	1889 Mar. 5.	*BRIGHT, CHARLES, F.R.S.E. ..	21 Old Queen Street, Westminster
	1889 Jan. 8.	*BRIGHT, PHILIP	2 Newgate Street, E.C.
	1904 Feb. 2.	*BRIGHTON, FREDERICK GRANT	H.M. Dockyard, Portsmouth.
	1886 Jan. 12.	*BRINCKMAN, WILLIAM HENRY	Glan y Bala, Llanberis, N. Wales.
	1900 Dec. 4.	*BRINDLEY, HARRY SAMUEL BICKERTON	3 Awoicho, Akasaka, Tokio, Japan
	1886 Apr. 6.	*BRINE, ERNEST AUGUSTUS ..	Elmcroft, Ashwood Road, Heath side, Woking.
	1897 Mar. 2.	BRISTED, RICHARD BOWER ..	c.o. R. F. Blair, 6 Eastcheap, E.C.
	1897 Apr. 6.	BRISTOW, ARTHUR GEORGE ..	St. Andrew's Works, Bury St Edmunds.
	1897 Jan. 12.	*BRISTOW, CHARLES THEODORE LYTTELTON	Promenade Offices, Colwyn Bay N. Wales.
	1892 Dec. 6.	BRITTAIN, SAMUEL GEORGE ..	Delta Light Rys., Tantah, Egypt.
	1896 Dec. 1.	BRITTEN, THOMAS JOHNSON ..	
C m ✠	1880 Mar. 2.	*BRITTON, PERCY WILSON ..	23 FitzGeorge Avenue, West Kensington, W.
	1894 Dec. 4.	BROAD, ALBERT EDWARD ..	8 Fitzroy St., Newtown, Sydney, N.S.W
	1904 Jan. 12.	*BROADBENT, FRANCIS JAMES..	University College, Bristol.
	1901 Dec. 3.	*BROADBRIDGE, WALTER ..	Sons of Gwalia Mine, Leonora, Western Australia.
	1902 Apr. 8.	*BRODHURST, HUGH, M.A. (*Cantab.*)	62 Old Tiverton Road, Exeter.
	1895 Dec. 3.	*BRODIE, JOHN BOYD	136 Wellington Street, Glasgow.
	1886 Dec. 7.	*BRODIE, JOHN SHANKS	Town Hall, Blackpool.
	1899 Dec. 5.	BRODIE, WILLIAM	Dockyard, Liverpool.
	1899 Dec. 5.	*BROMAGE, EDWIN ELLIOTT ..	Thames Conservancy, Embankment, E.C.
	1884 Jan. 8.	BROOKE, WALTER	Lympstone, Goddington Road, Rochester.
	1904 Apr. 12.	BROOKES, ALBERT MATTHEW..	G. W. R., Engineer's Office, Plymouth.
	1891 Dec. 1.	*BROOKS, ALBERT	Sir John Jackson, Admiralty Harbour, Simon's Town, S. Africa.
	1891 May 12.	*BROOKS, ALFRED	Tweed River Harbour Works, N.S.W.
✠	1899 Apr. 11.	BROOME, GEORGE HERBERT ..	P.O., Saskatoon, Saskatchewan, Canada.
	1897 Feb. 2.	BROSTER, ROBERT BUCK.. ..	Craven Bank Chambers, North Street, Keighley.
	1889 May 21.	*BROUGH, JOHN WATKINS ..	Fabrique de Ciment Portland, Raevels, Belgium.
m	1883 May 1.	*BROUGHTON, URBAN HANLON..	42 Broadway, New York, U.S.

	Date of Election.	ASSOCIATE MEMBERS.	
	1894 May 1.	Brown, Andrew	110 Cannon Street, E.C. (Browpost, London. Bank 647.)
	1890 Apr. 1.	*Brown, Arthur Richard	Billiter Square Buildings, E.C. (Embedded, London. Avenue 598.)
	1900 Apr. 3.	Brown, Charles John	Engineer's Office, North British Railway, Edinburgh.
	1901 Dec. 3.	Brown, Cuthbert	Boro' Surveyor and Water Engineer, Chelmsford.
	1887 Mar. 1.	Brown, Edward Johnson	16 Bigby Street, Brigg, Lincs.
	1883 Dec. 4.	*Brown, Frederick Benjamin	7 Albion Road, Sutton, Surrey.
	1882 May 23.	Brown, George William	Trollhättan, Alexandra Road, Reading (251).
	1900 Apr. 3.	Brown, James	21 Cranwich Road, Stamford Hill, N.
m	1893 Dec. 5.	*Brown, John Walter	57 Gracechurch Street, E.C. (Vitrified, London. Central 858.)
	1895 May 21.	Brown, Matthew Taylor, B.Sc. (*Glas.*)	233 St. Vincent Street, Glasgow.
	1892 Feb. 2.	*Brown, Peter Boswell	15 Osgathorpe Crescent, Sheffield.
	1897 Mar. 2.	Brown, Reginald	Public Offices, Southall, Middlesex.
	1877 Dec. 4.	Brown, Thomas Common	147 Woodbridge Road, Ipswich.
	1897 Dec. 7.	*Brown, William, B.Sc. (*Edin.*)	Irrigation Dept., Colombo, Ceylon.
f m	1902 Jan. 14.	*Brown, William Lowe, M.Sc. (*Victoria*)	Nile Reservoir, Assouan, Egypt.
	1903 Feb. 3.	*Browne, Benjamin Chapman, Jun.	8 Lambton Road, Newcastle-on-Tyne.
	1895 May 21.	*Browne, Gerard Macleay	4 Hanbury Street, Kalgoorlie, Western Australia.
	1889 Apr. 2.	Browne, John	Galdames Ry., Portugalete, Spain.
	1902 Jan. 14.	*Browne, William Lyon	Charing Cross, Euston & Hampstead Ry., 20 Victoria Street, S.W.
	1889 Dec. 3.	Browning, Robert Alexander	Gasworks, Neath.
	1887 Jan. 11.	*Brownridge, Charles	Boro' Engineer, Birkenhead.
	1892 Feb. 2.	Bruce, Henry	67 Crossgate, Cupar, Fife, N.B.
m ✠	1904 Jan. 12.	*Bruce, Robert	Engineer's Dept., London County Council, Spring Gardens, S.W.
	1895 May 21.	Bruce, Robert Arthur	Buckton & Co., Wellhouse Foundry, Leeds.
	1888 Apr. 10.	*Bruce, Robert Nigel Dalrymple, *Major 3rd W. Riding Regiment*	33 Belsize Crescent, Hampstead, N.W.
✠	1884 Mar. 4.	*Bruges, Charles Ernest	1 Victoria Street, S.W.
	1889 Apr. 2.	Brundrett, Alexander	1 Plasturton Avenue, Cardiff.
	1886 May 4.	Brunton, Philip George	Roads & Bridges Dept., Sydney, N.S.W.
	1889 Feb. 5.	*Brunton, Sydney Linton	Arc Works, Chelmsford.
	1900 Dec. 4.	Bryans, John George	Estacion Palermo, F.C. Pacifico, Buenos Aires.
	1900 Feb. 6.	Bryce, John	Burgh Surveyor's Office, Partick, Glasgow.
	1892 Dec. 6.	*Brydges, John Kempe	Electricity Works, Eastbourne.
	1894 Dec. 4.	*Buchan, James	Rhodesia Rys., Box 420, Bulawayo, South Africa.
	1884 Dec. 2.	Buchanan, James Beaumont	H. S King & Co., Pall Mall, S.W.
	1890 Jan. 14.	*Buchanan, John Blair	G. S. Buchanan, 21 Ashton Terrace, Glasgow.
	1899 Dec. 5.	Buchanan, John Hugh	5 Oswald Street, Glasgow.
	1903 Apr. 7.	*Buckley, Arthur Burton, Jun.	Contractor's Office, New Bute Dock, Cardiff.
	1900 Dec. 4.	Buckley, Herbert Edwin	Marlbro' Terrace, Park Road, Bingley.
	1895 Dec. 3.	Buckley, Joseph William	Gasworks, Falmouth.
	1897 Jan. 12.	Buckley, Michael James	26 Bessboro' Terrace, N.C.R., Dublin
	1894 Feb. 6.	*Bucknall, Harry	P.W.D., Jaffna, Ceylon.

Date of Election.	ASSOCIATE MEMBERS.	
1890 Feb. 4.	BUDHBHATTI, KESHAVJI SHAMJI	P.W.D., Bhuj, Cutch, India.
1896 Dec. 1.	*BULFIN, IGNATIUS, B.A (*Royal*)	Boro' Electrical Engineer, Southc Road, Bournemouth.
1888 May 15.	*BULL, HARRY FREESTONE ..	County Surveyor's Office, Chest
1881 Dec. 6.	BULL, JAMES	Valverde, Eaton Gardens, W. Brigh
1876 Mar. 7.	BULL, WILLIAM	c.o. Mrs. Bull, 153 Westbou Terrace, W.
1885 Dec. 1.	BULLOCK, CYRUS	67 King Street, Manchester.
1887 Mar. 1.	BULLOCK, FRANK	150 Leadenhall Street, E.C.
1885 May 19.	BULLOUGH, ROBERT CROSSLEY	55 Piccadilly, Manchester.
1890 Dec. 2.	BULLOUGH, THOMAS ALLEN ..	Delfside, Deacon Road, Applet Widnes.
1897 Apr. 6.	BULMAN, HARRISON FRANCIS ..	Barens Close, Burnopfield, Durham.
1890 Feb. 4.	BULMER, GEORGE HARLEY ..	Alquife, Guadix, Spain.
1891 Dec. 1.	*BULTEEL, HILLERSDEN ..	Naval Bank, Plymouth.
1883 Dec. 4.	*BUNNING, CHARLES ZIETHEN ..	c.o. British Consular Agent, P derma, Constantinople.
1891 Apr. 7.	BURDEN, ALEXANDER MITCHELL, B.E. (*Royal*)	County Surveyor, Kilkenny.
1874 Jan. 13.	*BURDER, WALTER CHAPMAN ..	Horticultural Works, Loughboro
1903 Apr. 7.	BURDON, HARRY	The Manse, Lasswade, N.B.
1896 Jan. 14.	BURDON, JOHN	101 Grosvenor Road, S.W.
1904 Feb. 2.	*BURFORD, ALFRED WILLIAM ..	94 Minard Road, Hither Gr Catford, S.E.
1904 Apr. 12.	*BURGE, HENRY	17 St. John's Road, Chelmsford.
1892 Apr. 5.	*BURGESS, ARTHUR JOHN ..	13 Woodstock Avenue, Redla Bristol.
1898 Mar. 1.	BURKITT, JAMES PARSONS, B.E. (*Royal*)	County Surveyor, Enniskill Ireland.
✠ 1898 Mar. 1.	BURLS, GEORGE ARTHUR ..	Steam Carriage Co., Homefi Chiswick, W.
1888 Dec. 4.	BURMAN, ERNEST SYDNEY ..	Town Hall, Melbourne, Victoria.
1904 Apr. 12.	*BURN, WALTER	Council Offices, Sutton-in-Ashfie
1895 Dec. 3.	*BURNE, EDWARD LANCASTER	88 Woodside Green, S. Norwood, S
1894 Mar. 6.	*BURNETT, CUTHBERT MILLER	24 Portland Street, Southampton.
1904 Jan. 12.	*BURRELL, JAMES THOMAS HAROLD RICHARD HUGH LEDICOTTE	15 Vernon Road, East Sheen, S.V
1886 Apr. 6.	*BURRELL, LEONARD	37 Rua Santa Luzia, Rio de Jane
1895 Dec. 3.	*BURROUGH, EDWARD SAVILLE	Eanswythe, Thornton Heath.
1895 May 21.	BURROWS, EDMUND	Swellendam, Cape Colony.
1885 May 19.	BURT, ARTHUR HAZELDEIN ..	Lismore, New South Wales.
1883 May 29.	*BURT, HENRY PARSALL	Oudh & Rohilkund Ry., Luckn India.
1896 Dec. 1.	*BURTON, AMOS	Borough Engineer, Stoke-on-Tre
1885 Dec. 1.	*BURTON, GEORGE LEWIS ..	Warren Road, Blundellsan Liverpool.
1894 Mar. 6.	BUSCARLET, FRANCIS CHARLES	N.E. Ry., Engineer's Office, Ne castle-on-Tyne.
1902 Apr. 8.	BUSH, WALTER ERNEST	Boro' Engineer, Sudbury, Suffolk
1895 Feb. 5.	BUSHE, ROBERT JOHN SCOTT	P.W.D., Georgetown, British Guia
1900 Feb. 6.	*BUSHELL, CHARLES LESTOURGEON	Grindlay, Groom & Co., Bombay.
1881 May 31.	BUSK, CHARLES WESTLY, M.A. (*Cantab.*)	Kokanee Creek, Nelson, Briti Columbia.
1896 Dec. 1.	BUTCHER, ARTHUR HOLT ..	The Vicarage, Brimscombe, Strou
t✠ 1895 Feb. 5.	BUTLER, DAVID BUTLER ..	41 Old Queen St., Westminster, S.
1884 Feb. 5.	BUTLER, JAMES	Merlewood, Kenilworth Road, Lea ington.
1904 Apr. 12.	BUTLIN, WILLIAM TRENTHAM SYMONS	Admiralty, 21 Northumberla Avenue, W.C.

	Date of Election.	ASSOCIATE MEMBERS.	
	1881 Dec. 6.	BUTT, HENRY WILLIAM	Eng.'s Office, S.E. Ry., London Bridge, S.E. [C.C.
m ✠	1899 Feb. 7.	*BUTTERWORTH, ARTHUR SHAW	Municipal Engineer, Port Elizabeth
	1902 Dec. 2.	*BYRDE, EDWIN AUGUSTUS ..	Bengal-Nagpur Ry., Pependaheo, Seoni Chappara, C.P., India.
	1889 Dec. 3.	BYRES, DAVID THOMSON ..	104 Hamilton Place, Aberdeen.
	1904 Apr. 19.	BYWATER, FREDERICK JONATHAN	Gas Works, Saltley, Birmingham.

	1877 Dec. 4.	CABEZAS, ADOLFO GARCIA ..	Matagorda Graving Dock, Cadiz.
	1889 Jan. 8.	CABLE, HENRY DARLINGTON ..	Brooklyn, Walsingham Rd., Hove.
✠	1892 Dec. 6.	*CACCIA, JULIAN EDWARD ..	24 Via Gino Capponi, Florence.
	1882 May 2.	*CAFFIN, FRANCIS CRAWFORD	Western House, Marlow, Bucks.
	1890 May 20.	*CAFFIN, HERBERT ALEXANDER	G.E. Ry., Lowestoft.
	1894 Jan. 9.	CAINK, THOMAS	Guildhall, Worcester.
	1886 Dec. 7.	CAIRNCROSS, THOMAS WILSON	Duncan Chambers, Shortmarket Street, Cape Town, C.C.
	1891 Apr. 7.	*CAIRNES, FREDERICK EVELYN	
	1896 Dec. 1.	CAIRN-HODGE, ARTHUR	Watson & Co., 7 Waterloo Place, S.W.
	1902 Dec. 2.	CALDER, WILLIAM	City Engineer, Prahran, Victoria.
	1883 Dec. 4.	*CALDICOTT, HARVEY	Sports Club, St. James's Square, S.W.
	1887 May 24.	CALLAN, NICHOLAS	Harbour Engineer, Dundalk.
	1884 May 6.	CALLCOTT, JOHN HOPE	Whitminster Lodge, Whitminster, Stonehouse, Glos.
	1886 Dec. 7.	CALLEN, THOMAS	
	1902 Dec. 2.	CALVERT, ERNEST ALDERSON	15 Tadema Road, Chelsea, S.W.
	1894 Dec. 4.	*CALVERT, THOMAS COPLEY ..	Maybank, Manly, N.S.W.
	1899 Feb. 7.	*CAMERON, ARCHIBALD PRESTON, B.A. (*Cantab.*)	Grindlay & Co., Calcutta.
	1901 Apr. 2.	*CAMERON, ARTHUR	Engineer's Office, N.E. Ry., Newcastle-on-Tyne.
	1885 Apr. 14.	CAMERON, JAMES	1 Maitland Avenue, Langside, Glasgow.
	1893 Dec. 5.	CAMERON, JOHN MINDORO ..	D.P.W., Sydney, N.S.W.
	1891 Dec. 1.	CAMERON, WILLIAM LOCHIEL SAPTE LOVETT	Superintending Engineer, Belgaum, India. [S.W.
	1885 Apr. 14.	CAMPBELL, ALBERT JOHNSTONE	22 Gledhow Gardens, S. Kensington,
	1899 Apr. 11.	*CAMPBELL, CHARLES ORR ..	Biddenham House, Biddenham, Bedford.
	1886 May 4.	CAMPBELL, GEORGE MURRAY ..	Mount House, Brasted, Kent.
	1883 Dec. 4.	CAMPBELL, ROBERT LEWIS ..	King, King & Co., Bombay.
	1886 Mar. 2.	CAMPBELL, WALTER HOPE ..	Egerton, Hubbard & Co., St. Petersburg.
	1875 Apr. 6.	*CAMPBELL, WILLIAM DUGALD	Cremorne Street, South Perth, W. Australia.
	1881 Apr. 5.	CAMPBELL-THOMPSON, JOHN ..	Hull.
	1894 May 22.	*CAMPION, FREDERIC ARTHUR	G.N. Ry., Peterborough.
	1892 Apr. 5.	CANBY, THOMAS	L. & N. W. Ry., Walsall.
	1878 Feb. 5.	CANET, GUSTAVE ADOLPHE ..	Avenue Henri Martin 87, Paris.
	1886 Jan. 12.	CANNING, THOMAS	Aragon House, Clytha Park, Newport, Mon.
	1899 Feb. 7.	CANNON, WILLIAM HENRY ..	St. Ronans, Leicester Road, New Barnet, Herts.
	1885 Dec. 1.	*CAPRON, ATHOL JOHN	Green Oak, Totley, Sheffield.
✠	1890 Jan. 14.	CARDEW, JOHN HAYDON	75 Pitt St., Sydney, N.S.W. (436.)
	1875 Feb. 2.	*CARDOZO, FRANCISCO CORREA DE M.	Pernambuco.
	1896 Mar. 3.	*CAREW-GIBSON, HARRY FREDERICK	Lake Copais Co., Moulki, Greece.

	Date of Election.	ASSOCIATE MEMBERS.	
	1893 Feb. 7.	*CAREW-GIBSON, JOHN GEORGE	Bridge House, Wallingford, Be
	1888 Jan. 10.	*CAREY, EVELYN GEORGE ..	Sunnyside Avenue, Udding Glasgow.
	1871 Mar. 7.	*CARFRAE, JAMES ALSTON ..	Holme Lodge, Wimbledon, S.W.
	1877 Dec. 4.	CARLINE, JOHN	Merivale, Catford Bridge, S.E.
	1894 Feb. 6.	*CARMICHAEL, GEORGE HENRY	Marwood View, Cothersi Darlington.
	1891 Mar. 3.	*CARNE, FREDERICK WILLIAM ..	Chenab Canal, Lyallpur, Punja
m ✠	1893 Dec. 5.	*CARNEGIE, DAVID	207 Abbeyfield Road, Sheffield.
	1903 Apr. 7.	CARNEGIE, FRANCIS	Laboratory, Arsenal, Woolwich.
	1902 Apr. 8.	CARNEGIE, WILLIAM	Laboratory, Arsenal, Woolwich.
	1889 Dec. 3.	*CARPENTER, JESSE FAIRFIELD	Cazenovia, New York, U.S.
	1889 Apr. 2.	CARPENTER, WILLIAM JOHN ..	Gasworks, Great Yarmouth.
	1891 Mar. 3.	*CARPMAEL, HENRY GIFFORD ..	3 St. Aubyns Mansions, Hove.
	1897 Apr. 6.	CARPMAEL, HERBERT	42 Barrow Road, Streat Common, S.W.
	1901 Feb. 5.	*CARPMAEL, RAYMOND	G.W. Ry. Harbour Works, G wick, Pembrokeshire.
	1894 Feb. 6.	*CARR, LAWRENCE STATTER ..	1 Craufurd Terrace, Maidenhe
	1889 Dec. 3.	*CARRICK, HENRY HAWKSHAW	N.E. Ry., Sunderland.
	1896 Jan. 14.	*CARROLL, ALEXANDER ERNEST	N. L. Ry., Engineer's Office, C den Town Station, N.W.
	1894 Dec. 4.	*CARTE, HUMFREY ALLEYNE ..	16 Lonsdale Road, Harborne, mingham.
	1892 Dec. 6.	*CARTE, RALPH GEORGE	P.W.D., Ceylon.
	1894 Dec. 4.	*CARTER, GEORGE FEARNLEY ..	Borough Engineer, Croydon.
	1871 Dec. 5.	*CARTER, HENRY	65 Victoria Street, S.W. (Sa tion, London.)
	1884 Dec. 2.	*CARTER, RODERICK EDMOND ..	c.o. H. S. King & Co., Pall Mall, S
	1900 Dec. 4.	*CARTER, WILLIAM BELLINGHAM, B.A.I. (*Dubl.*)	E. I. Ry., Sahebgunge, Bengal.
	1901 Apr. 23.	CARTER, WILLIAM CHARLES ..	27 Connaught Road, Harles N.W.
	1876 Feb. 1.	*CARTMELL, JOSEPH	Maryport and Carlisle Ry., Mary
	1904 Feb. 2.	*CARTWRIGHT, CECIL LEONARD	Braintree House, Cobham, Surre
	1902 Jan. 14.	CARTWRIGHT, EDMUND BRUCE WILLOUGHBY, M.A. (*Cantab.*)	1 Campden House Terrace, K sington, W.
	1895 Mar. 5.	*CARTWRIGHT, FRANK	Municipal Commission, How Bengal.
	1887 Dec. 6.	*CARUS-WILSON, CHARLES ASHLEY, M.A. (*Cantab.*) ..	41 Old Queen Street, Westmins S.W.
	1900 Dec. 4.	CARVER, THOMAS ALBERT BRIGGS, D.Sc. (*Glas.*)	118 Napiershall Street, Glasgow
	1890 Jan. 14.	*CARY, ARTHUR PITT CHAMBERS	66 Duke's Avenue, Chiswick, W
	1881 Apr. 5.	CARY, SULYARDE BERNARD ..	Himalayan Ry., Darjeeling, Ind
	1904 Jan. 12.	*CASE, CECIL BERTRAM	24 Ladbroke Gardens, Notting Hill
	1892 Jan. 12.	CASEBOURNE, CHARLES BASTOW	The Cottage, Greatham, Stock on-Tees.
	1891 Jan. 13.	*CASHMAN, WILLIAM ALOYSIUS, B.E. (*Royal*)	Eng.'s Office, G.W.Ry., Padding W.
	1891 Dec. 1.	CASTILLA, HENRY COUPER ..	P.W.D., Perth, Western Austral
	1884 Apr. 1.	CAVALCANTI, JOSÉ BARBALHO UCHÔA	Rua da Alfandega 6, Rio de Jane
	1892 Apr. 5.	CAWS, BYRON FRANK	R.E. Office, 44 Charing Cross, S.V
	1903 Apr. 7.	CHADWELL, CHARLES	Mervyn, Blackburn.
	1904 Jan. 12.	*CHADWICK, KENNETH MURRAY	City Engineer's Office, Leeds.
	1882 Mar. 7.	*CHADWICK, WILLIAM, F.C.H.	c.o. H. S. King & Co., Pall Mall, S.
	1893 Dec. 5.	CHALMERS, GEORGE	Villa Nova de Lima Estado Minas, Morro Velho, Brazil.
	1894 Mar. 6.	CHALMERS, NATHANIEL	Amabele-Butterworth Ry., Kong Eastern Province, Cape Colony.

	Date of Election.	ASSOCIATE MEMBERS.	
	1899 Dec. 5.	*Chamberlain, William Young	Harbour Office, Belfast.
	1904 Jan. 12.	*Chambers, Alfred Eustace	c.o. H. S. King & Co., 65 Cornhill, E.C.
	1890 Mar. 4.	*Chambers, Charles	Box 1049, Johannesburg, Transvaal.
	1904 Mar. 1.	*Chambers, Harry Kitson ..	H.M. Naval Establishment, Rosyth, Inverkeithing, N.B.
	1897 Mar. 2.	Chambers, Marcus Stanley	Preece & Cardew, 8 Queen Anne's Gate, Westminster, S.W.
	1893 Apr. 11.	Champion, Alfred John ..	12 Dartmouth St., Westminster, S.W.
t ✠	1891 Jan. 13.	Champion, Henry Vine, M.C.E. (*Melb.*)	87 Queen Street, Melbourne, Victoria.
	1878 Feb. 5.	Chancellor, John Thornton	104 Queen Victoria Street, E.C.
	1886 Dec. 7.	Chapman, Albert Barnes ..	Court House Chambers, Buxton.
	1883 Apr. 3.	*Chapman, Arthur Dodwell	Govt. Rys., Port Elizabeth, C.C.
	1897 Apr. 6.	Chapman, George Grant ..	Govt. Rys., Bulawayo, Rhodesia.
	1888 Dec. 4.	Chapman, George James ..	War Office, Horse Guards, S.W.
	1876 Mar. 7.	Chapman, James Lawrence ..	The Haven, Wembley.
	1900 Dec. 4.	*Chapman, Jesse Edward ..	Walter Scott & Middleton, Broadway, Worcestershire.
	1894 Dec. 4.	*Chapman, Samuel Christopher	Water Engineer, Torquay.
	1892 May 3.	*Chapman, Thomas Howard ..	P.W.D., Colombo, Ceylon.
	1900 Dec. 4.	*Charles, Alexis Amand Dallison	Elm Tree Lodge, Duffield, Derby.
	1886 Apr. 6.	*Charnock, *Professor* George Frederick	Technical College, Bradford.
	1887 Mar. 1.	*Charrington, Edmund	63 Queen Victoria Street, E.C.
m ✠	1892 Dec. 6.	*Chatterton, Alfred, B.Sc. (*Lond.*)	College of Engineering, Madras.
m	1894 Apr. 3.	*Chatterton, Bertram	10 Mundania Rd., Peckham Rye, S.E.
	1901 Mar. 5.	Chatwood, Arthur Brunel, B.Sc. (*Lond.*)	Prudential Buildings, Nelson Square, Bolton.
	1881 Dec. 6.	*Chauntler, Frank	Sunny Lawn, Weymouth. (205.)
	1899 Apr. 11.	*Cheeke, William Alexander	Baulking Grange, Faringdon, Berks.
	1900 Dec. 4.	Chettle, William Arthur ..	86 Haverhill Road, Balham, S.W.
	1898 Feb. 1.	Chetwynd, Henry Goulburn Willoughby	Tadworth, Epsom.
	1886 Apr. 6.	Child, George Charles ..	Kingston Metal Works, Smethwick, Birmingham.
	1883 May 29.	*Chipperfield, William Richard Hopkins	P.W.D., Port Elizabeth, Cape Colony.
	1888 May 1.	*Chisholm, Ross	
	1894 Feb. 6.	*Christ, Harry George, B.Sc. (*Lond.*)	82 Underhill Road, Lordship Lane, S.E.
	1881 Dec. 6.	Christie, Harry Bathurst ..	
	1890 Feb. 4.	Christie, William Innes ..	Central Ry., Rosario de Santa Fé, Argentina.
	1886 Dec. 7.	*Chubb, Harry Withers ..	43 Glengall Rd., Old Kent Rd., S.E.
	1897 Dec. 7.	Church, Richard James ..	Uganda Ry., Mombasa, East Africa.
	1899 Mar. 7.	Churchward, Ernest Coleridge	Bramwell & Harris, 34 North Bridge Street, Edinburgh.
✠	1879 Feb. 4.	*Churchward, William Patrick	Via Carlo Farini 9, Milano.
	1893 Dec. 5.	*Chute, John Henry Chaloner	Castle Coote, Roscommon, Ireland.
	1902 Jan. 14.	*Clapham, Walter	Saxonbury, Petersfield Road, Midhurst.
	1883 Jan. 9.	Clare, Jesse	Sleaford, Lincs.
	1885 Dec. 1.	Clark, Alexander	8 Bright's Crescent, Edinburgh.
✠	1888 Dec. 4.	*Clark, Edward George ..	Compañia Electricidad del Rio de La Plata, Casilla Correo 49, La Plata, Argentina.
M *f* ✠	1902 Feb. 4.	*Clark, Edward Vincent, B.S. (*Adelaide*)	54 Leander Road, Brixton Hill, S.W.

Date of Election.	ASSOCIATE MEMBERS.	
1899 Dec. 5.	*CLARK, FRANKLIN	H.M. Dockyard, Halifax, Nova Sc
1897 Jan. 12.	CLARK, GEORGE MUIRHEAD, M.A. (*Cantab.*)	Civil Service Club, Cape Town,
1891 Feb. 3.	*CLARK, GILBERT	183 Westcombe Hill, Blackheath,
1903 Feb. 3.	*CLARK, JOHN MARTIN	39A Philbeach Gardens, Kensing
1897 Dec. 7.	CLARK, LINDESAY COLVIN, M.C.E. (*Melb.*)	Briseis, Derby, Tasmania. [S
1894 Dec. 4.	*CLARK, WILLIAM BETHAM ..	Govt. Rys., Sierra Leone, W. Afr
1891 May 5.	CLARK, WILLIAM FREDERICK ..	The Poplars, Aldridge, Walsall.
1886 May 18.	CLARKE, CHARLES HARWOOD ..	Engineer's Dept., N.E. Ry., Ne castle-on-Tyne.
1890 Apr. 1.	*CLARKE, CHARLES STANLEY ..	17 Victoria Street, S.W.
1893 Feb. 7.	*CLARKE, EDMUND	Fernleigh, Trafalgar Road, Camb well, Victoria.
1899 Mar. 7.	CLARKE, FREDERICK WILLIAM	Harbour Works, Harrington, M ning River, N.S.W.
1901 Dec. 3.	CLARKE, GEORGE EDGAR ..	Boro' Surveyor, Boston, Lincs.
1901 Apr. 23.	CLARKE, HENRY MATTHIAS ..	Tanjong Pagar Dock Co., Singapo S.S.
1883 Dec. 4.	CLARKE, HENRY WILLIAM ..	New Bute Dock Contract, Cardif
1896 May 19.	CLARKE, HERBERT	E. C. Hare, Masonic Temple, S Francisco, Calif., U.S.
1896 Dec. 1.	CLARKE, HERBERT GEORGE ..	City Engineer's Office, Nottingha
1889 Dec. 3.	*CLARKE, JOHN FOLLIOTT MOSTYN	Surrey Commercial Docks, E gineer's Office, Rotherhithe, S.
1899 Apr. 11.	CLARKE, OWEN HENRY	Thames Conservancy, Victoria E bankment, E.C.
1904 Apr. 19.	CLARKE, RICHARD ELLIOTT ..	6 The Terrace, R.N. Hospit Haslar, Gosport.
1893 May 16.	CLARKE, RICHARD FREDERICK DODD	H. S. King & Co., Pall Mall, S.W
1899 Dec. 5.	CLARKE, ROBERT WILLIAM ..	
1890 Dec. 2.	*CLARKSON, THOMAS	Jesmond, Southborough Ro Chelmsford.
1898 Dec. 6.	CLARRY, WILLIAM ALFRED HENRY	Surveyor, Sutton Coldfield.
1895 Dec. 3.	*CLAYPOOLE, ALBERT HENRY ..	City Engineer's Office, Bristol.
1865 May 2.	CLAYTON, ALFRED	Hampton Street, Brighton, Victori
1893 Jan. 10.	*CLAYTON, FRANK, F.C.H. ..	King, King & Co., Bombay.
1895 Dec. 3.	*CLAYTON, RICHARD HAWORTH	Chestnut House, Horbury, Wakefiel
1888 Dec. 4.	*CLEAVER, HENRY LOWTHIAN ..	Eastern Bengal State Ry., Saidpo India.
1881 Mar. 1.	*CLEGG, CHARLES	
1900 Apr. 3.	CLEGG, HARRY	Boro' Surveyor's Office, Felixstow
1904 Jan. 12.	CLELAND, ALLAN FRASER ..	Stanthorpe, Queensland.
1904 Apr. 12.	CLEMENT, MILDMAY THOMAS CHARLTON, B.A.I. (*Dubl.*) ..	22 Waltham Terrace, Blackroc co. Dublin.
1879 Mar. 4.	CLEMINSON, JOHN	St. Paul's Chambers, Ludgate Hil E.C.
1872 Dec. 3.	CLEMMEY, WILLIAM HENRY ..	81 Trinity Road, Bootle, Liverpool
1874 May 12.	CLIMIE, WILLIAM	R. F. Cornwell, 80 Pine St., Ne York, U.S.
1898 Dec. 6.	*CLOTHIER, HENRY WILLIAM ..	Messrs. S. Z. de Ferranti, Hollin wood, Lancs.
1891 Dec. 1.	CLOUGH, ALFRED	74 Lark Lane, Sefton Park, Liverpoo
1891 Dec. 1.	COAKES, GEORGE SHOREY, B.A. (*Cape*)	Dundee, Natal.
1889 Dec. 3.	COALES, HERBERT GEORGE ..	District Council, Market Harborough
1885 Feb. 3.	COATES, THOMAS	The Poplars, Darlington.
1886 Feb. 2.	COATES, WILLIAM	95 Horton Grange Road, Bradford.
1890 Dec. 2.	COATH, DAVID DECIMUS	Rosenlaui, Elms Avenue, Muswel Hill, N.

Date of Election.	ASSOCIATE MEMBERS.	
1895 May 21.	*COBB, FREDERIC EDWARD THEODORE	Public Health Dept., Melbourne, Victoria.
1893 Dec. 5.	COBBETT, WILBERFORCE ..	62 West Street, Fareham, Hants.
1879 Apr. 1.	COBBOLD, EDGAR STERLING ..	All Stretton, Church Stretton, Salop.
1892 Dec. 6.	*COCHEMÉ, ALFRED ERNEST ..	Sirhind Canal, Ferozepore, India.
1889 Mar. 5.	*COCHRANE, FRANCIS JAMES ..	
1890 Apr. 1.	COCKBURN, *Sir* ROBERT, *Bart.*	Pennoxstone Court, Ross, Hereford.
1889 Mar. 5.	COCKBURN, SIDNEY MANTHORP	Rest Hotel, Kenton, N.W.
1898 Jan. 11.	COCKEY, FREDERICK GEORGE..	74 Overstrand Mansions, Battersea Park, S.W.
1894 May 1.	COCKRILL, THOMAS	Glencoe, Biggleswade, Beds.
1888 Feb. 7.	*COCKSHOTT, FRANCIS EDWARD	Manpur, Gya, Bengal.
✠ 1899 Feb. 7.	COKER, ERNEST GEORGE, M.A. (*Cantab.*), D.Sc. (*Edin.*) ..	McGill University, Montreal.
1900 Apr. 3.	COLE, CHARLES HENRY	H.M. Dockyard, Malta.
✠ 1886 Apr. 6.	*COLE, CHARLES JOHN	c.o. H. S. King & Co., 65 Cornhill, E.C.
1901 Apr. 23.	COLE, REGINALD SORRÉ, M.A. (*Cantab.*)	Church Road Station, Garston, Liverpool.
1876 Mar. 7.	COLE, THOMAS	11 Victoria Street, S.W. (Bisecting, London. Westminster 588.)
1890 Dec. 2.	*COLE, WILLIAM BARTHOLOMEW	Resident Engineer's Office, London Bridge Widening, Adelaide Place, E.C.
1895 Mar. 5.	COLEMAN, FREDERICK ALBERT	65 Calabria Road, Highbury, N.
1904 Jan. 12.	*COLEMAN, GEORGE STEPHEN ..	City Surveyor's Office, Manchester.
1893 Feb. 7.	*COLES, FRANCIS GEORGE	4 Shirley Road, Southsea.
1886 Dec. 7.	*COLES, WALTER JOSEPH	The Gables, Bass Street, Derby.
1893 Jan. 10.	COLLIER, HUGH MORTIMER HERBERT	New Dock Works, Middlesbro'.
1903 Apr. 7.	COLLINGE, THOMAS PEEL ..	City Engineer's Office, Carlisle.
1898 Dec. 6.	COLLINGRIDGE, HARVEY, B.Sc. (*Lond.*)	73 Grove Road, Wanstead, Essex.
1892 Dec. 6.	*COLLINS, ADRIAN CHARLES ..	61 Old Broad Street, E.C.
✠ 1891 Dec. 1.	*COLLINS, HENRY FRANCIS ..	J. H. Collins & Sons, Salisbury House, Finsbury Circus, E.C.
1877 Mar. 6.	COLLINS, HENRY RAMSAY ..	Russell Street, Durban, Natal.
1895 Dec. 3.	COLLINS, W. HEPWORTH ..	
1902 Jan. 14.	*COLLINS, WILLIAM	Wargrave, Croydon Road, Beckenham.
1897 Mar. 2.	*COLLINSON, ARTHUR	N. E. Ry. Loco. Dept., York.
1897 Apr. 6.	*COLLIS, OLIVER JAMES	Holmhurst, South Road, Brighton, Victoria.
1891 Mar. 3.	*COLLIS, WILLIAM HENRY ..	7 Barn Hill Road, Wavertree, Liverpool.
t ✠ 1888 Mar. 6.	*COLQUHOUN, WILLIAM	Plas Penyddoe, Bersham, Wrexham.
1887 May 24.	*COLTON, CHARLES ANDERSON COWARD	Gasworks, Sydney, N.S.W.
1898 Feb. 1.	*COLYER, MORETON JOHN GODDEN, B.E. (*Sydney*) ..	Wood Street, Manly, N.S.W.
1872 Apr. 9.	COMPTON, EDMUND	8 St. Anne's Crescent, Lewes.
1902 Jan. 14.	*CONACHER, JAMES	Formans & McCall, 160 Hope Street, Glasgow.
1899 Dec. 5.	CONCANNON, THOMAS GEORGE UPTON	Municipal Engineer, Prome, Burma.
1887 Dec. 6.	CONCEIÇÃO, JOSÉ MARIA DA ..	Caixa 321, Rio de Janeiro.
1890 Mar. 4.	*CONES, JAMES ALFRED	L. Ganges Canal, Etawah, N.W.P., [India.
1888 May 15.	CONEY, JOHN ROBERT	Meadowfield, Sleaford, Lincs.
1897 Jan. 12.	CONNER, BENJAMIN	9 Scott Street, Glasgow.
1896 Dec. 1.	*CONRADI, JULES FERDINAND ..	Great Central Ry., Leicester.

Date of Election.		ASSOCIATE MEMBERS.	
	1892 Dec. 6.	CONSTANTINE, EZEKIEL GRAYSON	17 St. Ann's Square, Mancheste
	1892 May 3.	*CONYERS, SIDNEY WARD ..	Ry. Construction Dept., Syd N.S.W.
	1874 Feb. 3.	CONYERS, WILLIAM	483 Collins St., Melbourne, Vict
	1902 Dec. 2.	*COODE, ARTHUR TREVENEN, B.A. (*Cantab.*)	3 Earl's Avenue, Folkestone.
	1887 Dec. 6.	*COOK, FRANK PLANT	Mansfield Woodhouse, Notts.
	1893 Jan. 10.	COOK, JOHN	City Engineer, Cape Town, C.C.
	1901 Mar. 5.	COOK, STANLEY SMITH, B.A. (*Cantab.*)	33 Lisk Avenue, Whitley Northumberland.
	1882 May 23.	COOKE, CHARLES EDWARD ..	City Council Office, Auckland,
	1898 Dec. 6.	COOKE, CONRAD ALAN	B.B. & C.I. Ry., Ahmedabad, In
	1883 May 29.	*COOKE, FREDERICK GEORGE ..	3 Hyde Gardens, Eastbourne.
	1897 Mar. 2.	COOKE, STUART BLASHFIELD REA	Southcroft, Westgate-on-Sea.
	1904 Apr. 19.	COOKE-YARBOROUGH, HENRY ALFRED	40 Elmore Road, Sheffield.
	1895 Feb. 5.	COOKSEY, DANIEL FREDERICK	Corsley Villa, Western Elms Ave Reading.
	1895 Dec. 3.	*COOKSON, ALFRED CHORLEY ..	G. W. Ry., Eng.'s Office, West Eal
	1900 Jan. 9.	COOKSON, THOMAS	Town Hall, Preston.
	1888 Dec. 4.	*COOMBER, WILLIAM HORACE ..	Lancs. and Yorks. Ry., Manches
	1891 Dec. 1.	COOPER, ALFRED ERNEST ..	Société de Travaux, Chemin de Pirée-Demirly, Lamia, Greec
	1897 Apr. 6.	COOPER, FRANCIS EDWARD ..	13 Norma Rd., Waterloo, Liverp
	1894 May 1.	COOPER, LEONARD	F.C. Sud., Buenos Aires.
	1896 May 5.	COOPER, THOMAS, M.A. (*Cantab.*)	Spring Valley, St. Albans.
	1896 Feb. 4.	*COOPER, THOMAS BRAMMALL, B.Sc. (*Victoria*)	E. Nuttall, Cumberland R Bristol.
	1902 Apr. 22.	*COOPER, VERNON	F. C. Interoceanico, Peubla, Mex
	1886 May 18.	COOPER, VIVIAN BOLTON DOUGLAS	22 Buckingham Gate, S (Megohm, London.)
	1904 Jan. 12.	*COOPER, WALTER GOUGH ..	152 Elgin Avenue, W.
	1874 Feb. 3.	COOPER, WILLIAM	Neptune Engine Works, Hull. (N tune, Hull. 30.)
	1892 Mar. 1.	COOPER, WILLIAM	Table Bay Harbour, Cape Colony
t ✠	1900 Dec. 4.	COOPER, WILLIAM RANSON, M.A., B.Sc. (*Royal*)	113 Upper Tulse Hill, S.W.
	1894 Feb. 6.	*COPE, WILFRED ARTHUR ..	District Council, Bromley, Kent.
	1890 Dec. 2.	COPELAND, HENRY PAUL RAMSAY, *Major N.S.W.M.R.*	Eckstein & Co., Johannesb Transvaal.
	1902 Dec. 2.	COPLAND, CHARLES AUGUSTUS	Hornsea, Grange Road E., Midd brough.
	1893 Dec. 5.	*COPLAND, JOHN PEARSON ..	15 Holyrood Crescent, Glasgow.
m	1895 Dec. 3.	*COPLAND, WILLIAM ROBERTSON, JUN.	146 West Regent Street, Glasgo
	1890 Dec. 2.	COPLAND, WILLIAM WALLACE	Sanitary Commission, Gibraltar.
	1894 Dec. 4.	COPLEY, CHARLES THOMAS ..	252 Barkerhouse Rd., Nelson, La
	1896 Apr. 14.	*CORBETT, PATRICK JOSEPH ..	c.o. H. S. King & Co., Pall M S.W.
	1890 Apr. 1.	CORDNER-JAMES, JOHN HENRY	Finsbury House, Blomfield St., E
	1893 Dec. 5.	*CORIN, WILLIAM	Town Hall, Launceston, Tasman
✠	1902 Apr. 8.	CORMACK, *Professor* JOHN DEWAR, B.Sc. (*Glas.*) ..	University College, Gower St., W
	1892 Dec. 6.	CORNER, CHARLES	Rhodesia Rys., Bulawayo, S. Afri
✠	1898 Dec. 6.	CORNISH, NICHOLAS EDWARD ..	Imperial Arsenal, Shanghai, Chi
	1875 Apr. 6.	CORNISH, THOMAS SMERDON ..	Belfield House, East Coast, Demera
	1901 Feb. 5.	*CORNOCK, JOSEPH CAPEL ..	90 Tempest Road, Beeston Hill, Lee
	1897 Apr. 6.	CORNEWALL-WALKER, ARCHIBALD EDWARD	East Surrey Water Co., Redhill.
	1902 Dec. 2.	CORRIE, WILLIAM EDWARD, B.Sc. (*Victoria*)	Railways, Rangoon, Burma.

Date of Election.	ASSOCIATE MEMBERS.	
1902 Apr. 8.	CORRINGHAM, GEORGE HENRY	Airedale, Bridge View, Kirkstall, Leeds.
1866 May 15.	COTTERILL, JAMES HENRY, M.A. (*Cantab.*), F.R.S.	Braeside, Speldhurst, Kent.
1877 Feb. 6.	COTTRELL, HENRY EDWARD PLANTAGENET	c.o. Mrs. Cottrell, 12 Cavendish Road, Balham, S.W.
1902 Mar. 4.	*COTTRELL, WILLIAM RICHARD THOMAS	60 Thornton Avenue, Chiswick, W.
1879 Feb. 4.	COUPER, FREDERICK	New River Office, Clerkenwell, E.C.
1902 Mar. 4.	*COUPER, JOHN DUNCAN CAMPBELL, M.A. (*Cantab.*)	80 Grosvenor Street, W.
1897 Dec. 7.	*COUTTS, ERNEST GRAY	c.o. H. S. King & Co., Pall Mall, S.W.
1896 May 19.	COVENTRY, HENRY GEORGE	Rothbury, Northumberland.
1897 Mar. 2.	*COVERNTON, RALPH HENRY	Municipal Electric Light Works, Johannesburg, Transvaal.
1900 Feb. 6.	*COWAN, JAMES MARSHALL, B.A. (*Cantab.*)	Redpath, Brown & Co., Riverside Works, East Greenwich, S.E.
1890 Feb. 4.	*COWAN, JOHN	179 West George Street, Glasgow.
St ✠ 1903 Apr. 7.	*COWAN, PERCY JOHN	E. R. A. Loco. Dept., Boulac, Cairo.
1889 Dec. 3.	COWARD, GEORGE EDWARD	c.o. Stilwell & Sons, 42 Pall Mall, S.W.
1899 Apr. 11.	COWDERY, GEORGE ROBERT	Glencoe, Torrington Road, Strathfield, N.S.W.
1900 Dec. 4.	*COWLE, GERALD ARTHUR	P.O., Schenectady, New York State, U.S.
1874 Jan. 13.	*COWPER, CHARLES EDWARD	8 Sandown Terrace, Deal.
1896 Dec. 1.	*COWPER-COLES, SHERARD OSBORN	26 & 27 Grosvenor Mansions, Victoria Street, S.W.
1897 Apr. 6.	COX, DOUGLAS BRENTON	Govt. Rys., Maritzburg, Natal.
1892 Dec. 6.	*COX, FREDERICK NUTTER	San José, Costa Rica.
1893 May 2.	COX, FREDERICO WILLIAM	Uzina Conçanção de Sininbu, São Miguel dos Campos, Alagoas, Brazil.
1876 Dec. 5.	*COX, GRIFFITH NATHANIEL	Kingston, Jamaica.
1883 Jan. 9.	*COX, HORACE BOARDMAN	
1881 Mar. 1.	COX, THOMAS ADEY, B.A.	14 Hazlitt Road, W. Kensington, W.
1886 Dec. 7.	*CRABTREE, HENRY HERBERT	S. Pearson & Son, Mexico.
1895 Dec. 3.	*CRABTREE, WALTER ROBINSON, M.Sc. (*Victoria*)	Union Offices, High Street, Doncaster.
1891 Dec. 1.	*CRABTREE, WILLIAM ROBSON	Harbour Works, East London, Cape Colony.
1903 Apr. 7.	CRAGGS, HENRY WELDON	35 City Road, Edgbaston, Birmingham.
✠ 1900 Dec. 4.	*CRAIG, ALEXANDER DONALD, B.E. (*Sydney*)	P.W.D., Sydney, N.S.W.
1899 Dec. 5.	*CRAIG, ALEXANDER GRATITUDE, B.Sc. (*Glas.*)	Tympany, Penicuik, Edinburgh.
1889 Dec. 3.	*CRAIG, CLARENCE	Tyrella House, Clough, co. Down.
1901 Dec. 3.	CRAIG, WALTER LENNOX, B.C.E. (*Melb.*)	196 Barkly Street, St. Kilda, Melbourne, Victoria.
1896 Apr. 14.	CRAIG, WILLIAM	P.W.D., Cape Town, C.C.
1891 Mar. 3.	CRAVEN, ALBERT WILLIAM	179 Collins St., Melbourne, Victoria.
1875 May 4.	CRAVEN, CHARLES ALFRED	Gasworks, Savile Town, Dewsbury.
1903 Mar. 3.	CRAWLEY-BOEVEY, ARTHUR CURTIS, B.A. (*Oxon.*)	Lancaster Villas, Newcastle.
1894 Mar. 6.	*CRAWTER, FRANK WHINFIELD	Chloride Electrical Storage Co., 39 Victoria Street, S.W.
1884 Feb. 5.	CREER, ALFRED	The Guild Hall, York.
1904 Jan. 12.	CREGEEN, HUGH STOWELL	Ashdene, Enslin Road, Eltham, S.E.
1896 Apr. 14.	CRESSWELL, GEORGE BELBEN	King, Hamilton & Co., Calcutta.
1883 May 29.	CRESSWELL, JOSEPH	54 Castle Street, Dover.

Date of Election.	ASSOCIATE MEMBERS.	
1893 May 16.	Creswell, Frederic Hugh Page	Rand Club, Johannesburg, Transvaal.
1884 Dec. 2.	Crichton, William Bateman	2 Collingwood Street, Newcastle-on-Tyne.
1894 Dec. 4.	*Crighton, Charles	S. Indian Ry., Negapatam.
1888 Dec. 4.	Cripps, Frederick Southwell	71 King William Street, E.C.
1881 Dec. 6.	*Croft, Henry	Victoria, British Columbia.
1895 May 21.	*Crompton, Reginald Harratt	11 Lowther Street, Whitehaven.
1892 Mar. 1.	*Crook, John Rowland	Government Engineer, Gibraltar.
1895 Dec. 3.	Crookes, Bernard Humphrey, M.Sc. (*Victoria*)	34 Devonshire Place, Jesmond-on-Tyne.
1879 May 27.	Crossie, James	New Farm, Gamlingay, Sandy.
1902 Apr. 22.	*Crosland, James Charles Herbert	Belcombe, Hale, Cheshire.
1887 May 24.	Crosley, William	54 St. James' Square, Notting Hill, W.
1891 Dec. 1.	Cross, Alfred McCallum	Kamberg, Rosetta, Natal.
1882 Apr. 4.	*Cross, Ambrose Wootton	Glendale, School Road, Moseley, Birmingham. [Walsall. S
1887 Dec. 6.	*Cross, Frederick William	45 Bradford Street, Walsall. (Iro
1896 May 5.	Cross, Frederick William	Gasworks, Leyton, Essex.
1904 Jan. 12.	*Cross, William Mark, B.A., B.E. (*Royal*)	21 Lilymead Avenue, Totterdown, Bristol.
✠ 1888 Feb. 7.	Crosthwaite, Ponsonby Moore, B.A.I. (*Dubl.*)	Coode & Matthews, 9 Victoria Street, S.W.
1899 Dec. 5.	*Crouch, John Peachey	L. & Y. Ry. Works, Horwich, Lanc
1891 Feb. 3.	Crowe, Percy Barry Gustav Otto	27 Old Queen Street, Westminster, S.W.
1894 Dec. 4.	Crowther, James Alfred	Boro' Engineer, Southampton.
1892 Jan. 12.	Crozier, William, Jun.	Shire Hall, Durham.
1887 Dec. 6.	Crummack, Harker Charles	Boro' Engineer, Hartlepool.
1881 May 31.	Cubitt, William	Rumney House, Cardiff.
1891 Dec. 1.	*Cuffe, Otway Fortescue Luke Wheeler	P.W.D., Mandalay, Burma.
1895 Apr. 2.	Cullen, Herbert Dale	Sherwood, Armadale, Western Australia.
1904 Apr. 19.	*Culley, Alfred Edwin	Priory Farm, Sale, Cheshire.
1890 Jan. 14.	Cullis, Edmund Joseph	Southgate Chambers, Gloucester.
1902 Jan. 14.	Cumming, Alexander George Gordon, B.Sc. (*Edin.*)	79 Princes Street, Edinburgh.
1897 Apr. 6.	Cunha, Luiz Gonçalves da	Société des Travaux à l'Etranger, Rue Acharnon 37, Athens.
1895 Dec. 3.	Cunningham, Brysson, B.E. (*Royal*)	Dockyard, Liverpool.
1903 Apr. 7.	*Cunningham, Harry	18 Knowe Terrace, Pollokshields, Glasgow.
1875 Jan. 17.	Cunningham, James Henry	2 Ravelston Place, Edinburgh.
1898 Dec. 6.	Cunnold, Clement Allan	Farra, Cambridge Road, Cottenham Park, Wimbledon.
1883 Dec. 4.	*Curry, William Elmitt	Woodoaks Farm, nr. Rickmansworth
1888 Jan. 10.	Curry, William Thomas	Ruabon, North Wales.
t ✠ 1890 May 6.	Curtis, Alfred Harper, B.A. (*Lond.*)	Carleton Lodge, Lower Walmer, Kent.
1903 Feb. 3.	Cusack, Ralph Smith Oliver	Furry Park, Raheny, co. Dublin.
1893 Apr. 11.	Cushny, John	Box 2237, Johannesburg, Transvaal.
1892 Dec. 6.	*Cust, Leopold	99 Onslow Square, S.W.
1894 May 1.	*Cutbill, Harry Wallace	Bogota, U.S. Colombia.
1890 Dec. 2.	Cuthbert, George Blythe	Cambridge, South Africa.
1900 Dec. 4.	Cutler, Arthur Edward	Magie Street, Mosmans, Sydney, N.S.W.
m ✠ 1886 Dec. 7.	*Cutler, Henry Albert	City Engineer, Belfast.
1874 May 12.	Cutler, Samuel	Providence Ironworks, Millwall, E
1896 Dec. 1.	Cutten, Frederick Alfred	Cutten Brothers, Dunedin, N.Z.

Date of Election.	ASSOCIATE MEMBERS.	
1904 Jan. 12.	DACK, WILLIAM HERBERT ..	South African Ironworks, Durban, Natal.
1889 Dec. 3.	DADABHOY, CURSETJEE	Cumballa Hill, Bombay.
1888 May 1.	DADABHOY, RATANSHAW	Bombay Ironworks, Bombay.
1891 Mar. 3.	DADLEY, BENJAMIN BAINES ..	47 Victoria Street, S.W.
✠ 1882 May 2.	DALES, JOHN HANDSLEY	Baithwaite & Co., 325 Finsbury Pavement House, E.C.
✠ 1898 Dec. 6.	*DALGLEISH, GEOFFREY SCOTT, B.Sc. (*Edin.*)..	c/o National Bank of Egypt, Cairo.
1881 May 31.	DALLAS, JOHN EDWIN	c/o H. S. King & Co., Pall Mall, S.W.
1895 Feb. 5.	*DANA, ROBERT WASHINGTON, M.A. (*Cantab.*)	15 Neville Street, Onslow Gardens, S.W.
1898 Dec. 6.	*DANIEL, ARTHUR HENRY ..	Hall Street, Cheadle, Cheshire.
1902 Dec. 2.	*DANIEL, WALTER	Admiralty Works, Hong Kong.
1874 Apr. 14.	DARBISHIRE, CHARLES HENRY	Plas Mawr, Penmaenmawr.
✠ 1892 Dec. 6.	*DARE, HENRY HARVEY, M.E. (*Sydney*)	Roads and Bridges Dept., Sydney, N.S.W.
1883 Dec. 4.	DARLINGTON, FREDERICK ARTHUR	168 Telford Avenue, Streatham Hill, S.W.
1877 Feb. 6.	DARWIN, HORACE, M.A. (*Cantab.*)	Huntingdon Road, Cambridge.
1873 Mar. 4.	DARWIN, SAMUEL BROTHERS ..	7 Heath Road, Petersfield, Hants.
1902 Feb. 4.	*DAS, RONESCHANDRA	Panchanuntolah, Howrah, Bengal.
1890 Apr. 1.	*DAVENPORT, CHARLES EDWARD	Inglewood Park Road, Nantwich.
1900 Mar. 6.	DAVENPORT, GEORGE ROBERT	Casilla del Correo 796, Buenos Aires.
1892 Dec. 6.	*DAVEY, GEORGE REGINALD ..	11 Kingsley Road, Plymouth.
1882 Dec. 5.	DAVIDSON, JOHN GEORGE ..	Caledonian Canal, Inverness.
1882 May 2.	DAVIDSON, JOHN PATON	Parry & Co., Madras.
1900 Jan. 9.	*DAVIDSON, JONATHAN ROBERTS, M.Sc. (*Victoria*)	Water Engineer's Office, Liverpool.
1891 Mar. 3.	DAVIES, DAVID	Cowell House, Llanelly.
1903 Apr. 7.	*DAVIES, EDWARD AYERST ..	124 Croydon Road, Anerley, S.E.
1895 Jan. 8.	DAVIES, JOHN HUBERT	Box 1386, Johannesburg, Transvaal
1897 Apr. 6.	DAVIES, JOHN HUGH	Cymry, Mooroopna, Victoria.
1876 May 2.	DAVIES, JOHN JOSEPH	Richmond, Brisbane Street, Perth W. Australia.
1888 Dec. 4.	DAVIES, MORGAN WILLIAMS ..	3 Gloucester Place, Swansea.
1876 Apr. 4.	DAVIES, THOMAS WILBERFORCE	41 Park Place, Cardiff.
1888 Dec. 4.	DAVIES, WILLIAM AUGUSTUS ..	Town Hall Chambers, High Street, Hounslow, W.
1896 Dec. 1.	DAVIES, WILLIAM PHILIP ..	Westfield, Abergavenny.
1893 Dec. 5.	DAVIS, ARTHUR CHAMIER ..	P.W.D., Hyderabad, Deccan, India.
1897 Apr. 6.	*DAVIS, CLEMENT FREDERICK, B.A. (*Cantab.*)	Osmington, Priestlands Road, Sidcup.
1903 Apr. 7.	DAVIS, FRANK WILLIAM ..	Cleveland Bridge Co., Gateshead-on-Tyne.
1899 Dec. 5.	*DAVIS, FREDERICK WILLIAM DANIEL, M.Sc. (*Victoria*) ..	S. Pearson & Son, Breakwaters, Malta.
1875 Jan. 12.	DAVIS, HARRY LOUIS	G.E. Ry., Eng.'s Office, Liverpool Street, E.C.
1891 Jan. 13.	*DAVIS, NEVILLE BROOKES ..	Waterworks Office, Leicester.
1901 Dec. 3.	DAVIS, WILLIAM HARRY	49 Wyatt Road, Forest Gate, E.
1891 Feb. 3.	*DAVISON, AUGUSTINE CAMPBELL	366 Camden Road, N.
1903 Apr. 7.	*DAVSON, SIMON SILVER	17 Granville Street, Aylesbury.
1891 Dec. 1.	*DAVY, JOHN	Caixa 403, Rio de Janeiro.
1896 Feb. 4.	DAWBARN, GILBERT JOSEPH, B.Sc. (*Glas.*)	School of Mines, Ballarat, Victoria
1901 Mar. 5.	*DAWE, JOHN NANSCAWEN, B.Sc. (*Glas.*)	Midland Railway, Sea Mills Station, Bristol.
1899 Feb. 7.	*DAWE, PHILIP HENRY	British Thomson Houston Co. Rugby.
1871 Apr. 4.	DAWNAY ARCHIBALD DAVIS ..	39 Victoria Street, S.W.

	Date of Election.	ASSOCIATE MEMBERS.	
	1894 May 1.	*DAWNEY, ALBERT EDWARD ..	c.o. W. Dawney, 125 Bethune Ro Stamford Hill, N.
	1893 Dec. 5.	*DAWSON, FREDERIC JOHN ..	P.W.D., Pretoria, Transvaal.
	1875 Dec. 7.	DAWSON, JAMES HENRY	The Grange, Tilford, Farnha Surrey.
	1895 Feb. 5.	*DAWSON, JOHN SMITH	45 Osborne Road, Blackpool.
	1894 May 1.	DAWSON, PHILIP	29 Great George Street, S.W.
W M ✠	1879 Dec. 2.	*DAWSON, WILLIAM BELL, M.A., D.Sc. (*McGill*)	Marine Dept., Ottawa, Canada.
	1894 Feb. 6.	DAWSON, WILLIAM SAMUEL ..	Pumping Station, Spottiswood Victoria.
	1904 Jan. 12.	DAY, ARTHUR ALBERT	33 Hartington Road, Bolton, Lan
	1899 Dec. 5.	*DAY, CLAUD ALBERT STAINTON	Grosvenor House, Isleworth, W.
	1903 Apr. 7.	*DEAKIN, GEORGE WELSBY ..	Waterworks, Talgarth, Brecon.
	1891 May 5.	DEAKIN, THOMAS HEDGES ..	Parkend, Lydney, Glos.
	1902 Dec. 2.	*DEANE, HENRY JAMES, B.E. (*Sydney*)	2 Queen Square Place, Westmi ster, S.W.
	1891 Jan. 13.	*DEANS, HAROLD, B.A. (*Cantab.*)	Engineer's Office, G. W. Ry., Pa dington, W.
	1895 Jan. 8.	DEARDEN, HENRY	Boro' Engineer, Dewsbury.
	1900 Jan. 9.	DEAS, JAMES	Water Engineer's Office, Warringt
	1881 May 3.	DEASE, PATRICK PAGET	Les Sapins, Dinan, France.
	1882 Dec. 5.	D'EBRO, CHARLES ABRAHAM ..	99 Queen St., Melbourne, Victori
	1897 Dec. 7.	*DELAP, ALFRED DOVER, B.A.I. (*Dubl.*)	Resident Engineer's Office, Rossla co. Wexford.
m	1890 Apr. 1.	*DELVES-BROUGHTON, VERNON WARBURTON	80 Central Hill, Upper Norwo S.E.
	1885 Dec. 1.	DE MELLO, CHARLES HARVEY	King, Hamilton & Co., Calcutta.
✠	1898 Mar. 1.	DEMPSTER, HERBERT GEORGE	Seaford, Richmond, Natal.
	1895 May 21.	DENHAM, HENRY MANGLES ..	Ashbourne House, Rainhill, Lanc
	1886 Dec. 7.	*DENISON, GEORGE CHARLES ..	2 Strathmore Gardens, Kensingto W.
	1887 Dec. 6.	DENISON, JOSEPH BASIL	Bembridge, Isle of Wight.
	1881 May 31.	DENNIS, HENRY	Ruabon, N. Wales. (Dennis, Ruabo
	1893 Dec. 5.	DENNIS, NELSON FREDERICK ..	Boro' Engineer, West Hartlepool.
	1881 Apr. 5.	*DENT, HASTINGS CHARLES ..	The Homestead, South Godsto Surrey.
	1886 Dec. 7.	DENTON, HENRY RICHARD JOHN	TorLodge, Compton, Wolverhampt
	1885 Dec. 1.	DETSI, MIGUEL	Rua do Imperador 8, Petropolis, F de Janeiro.
	1902 Dec. 2.	DEVENISH, JAMES ALDRIDGE	King, King & Co., Bombay.
	1894 May 1.	*DEVENISH-MEARES, BASIL, B.A.I. (*Dubl.*)	Govt. Rys., Kei Road, Cape Colo
	1889 Feb. 5.	*DEVÉRIA, LEWIS MARIE THEODULE	22 Lower Kemmendine Road, Ra goon, Burma.
m	1897 Jan. 12.	*DE VILLE, MARTIN	Ardlui, Fairdene Road, Purley Ro Surrey.
	1883 May 1.	*DEVONSHIRE, THOMAS EASTON	Purbright, Chislehurst.
	1899 Dec. 5.	DHIRAJRAM, HIMATLAL (*Rao Bahadur*)	Ahmedabad, Bombay.
	1891 Dec. 1.	DHUNJIBHOY, RUTTONJI, *Khan Sahib*	31 1st Marine Street, Dhobi Tal Bombay.
	1894 Dec. 4.	DIAZ-LOMBARDO, ISIDRO	Calle de Cocheras 11, Mexico.
	1888 Apr. 10.	DIBLEY, GEORGE	Gaveston Place, Nuthurst, Sussex
	1895 Dec. 3.	DICK, DAVID CRAWFORD.. ..	Engineering Department, Cust House, Shanghai.
	1886 Dec. 7.	*DICKIE, ALEXANDER LOW ..	Barry Ry., Caerphilly, S. Wales.
	1899 Dec. 5.	DICKINSON, HAROLD	Woodfield, North Park Ro Roundhay, Leeds.
	1888 Dec. 4.	DICKINSON, THOMAS RUSHOLM	Burton House, Clifton, York.
	1879 Dec. 2.	*DICKSON, JOHN	Glaisdale Grange, Whitby.

Date of Election.	ASSOCIATE MEMBERS.	
1888 Dec. 4.	DIESELHORST, WILLIAM	182 Victoria Road, Charlton.
1881 Dec. 6.	DIGGLE, JAMES	Water Engineer, Heywood.
1900 Jan. 9.	*DILLEY, WILFRID JOSEPH, B.Sc. (*Edin.*)	Polytechnic School of Engineering, Cairo.
1885 Feb. 3.	*DISNEY, GEORGE WILLIAM ..	B. & N. W. Railway, Muzafferpur, India.
1893 Dec. 5.	*DIX, HARRY ARTHUR	6 Rigby Road, Blackpool.
1902 Mar. 4.	*DIXON, ARTHUR	5 Cheapside, Bradford (Construct, Bradford).
1893 Jan. 10.	DIXON, FRANCIS EDWARD ..	49 Lune Street, Preston.
1892 Dec. 6.	*DIXON, FREDERIC BRERETON ..	c.o. W. Dixon, 50 Friends Road, Croydon.
1897 Apr. 6.	DIXON, FREDERIC JOHN	Prospect Crescent, Harrogate.
1897 Mar. 2.	DIXON, JAMES RUSH	Town Hall, Old Street, E.C.
1892 Dec. 6.	*DIXON, ROBERT BLAND, R.N.	H.M. Dockyard, Portsmouth.
1896 Dec. 1.	DIXON, RODEN	Boro' Surveyor, Stratford-on-Avon.
1892 Dec. 6.	*DIXON, STEPHEN MITCHEL, M.A., B.A.I. (*Dubl.*)	Dalhousie College, Halifax, Nova Scotia.
t ✠ 1900 Dec. 4.	*DOAK, WALTER JAMES, B.E. (*Sydney*)	Engineer's Office, Railway Dept., Brisbane, Queensland.
1904 Jan. 12.	DOBBIE, JOHN	65 Bath Street, Glasgow. (388.)
1897 Feb. 2.	*DOBSON, ARTHUR AUSTIN GREAVES	c.o. H. A. Dobson, 75 Eaton Rise, Ealing, W.
1897 Feb. 2.	DOBSON, DOUGLAS	Boro' Engineer, Masterton, N.Z.
1883 Feb. 6.	*DOCKRAY, JOHN ARTHUR ..	Chelston Bank, Torquay.
1901 Dec. 3.	*DODD, EDWARD	37 Waterloo Street, Birmingham. (Culvert, Birmingham. 04718.)
1891 Jan. 13.	*DODD, FRANK WILLIAM	Portland Harbour Torpedo Works, Weymouth.
1890 Dec. 2.	DODD, PETER	Surveyor's Office, Wandsworth, S.W.
1902 Dec. 2.	*DODD, ROBERT PARKER ..	37 Waterloo Street, Birmingham.
1894 Jan. 9.	*DODS, JOSHUA CHALMERS ..	Cannamore, Malabar, India.
1894 Mar. 6.	*DONALD, PATRICK DUNLOP, B.Sc. (*Glas.*)	Annandale, Kilmarnock.
t ✠ 1898 Mar. 1.	*DONALDSON, THORNYCROFT, M.A. (*Cantab.*)	2 Melbury Road, Kensington, W.
1898 Apr. 5.	*DONKIN, SYDNEY BRYAN ..	Dr. Kennedy, 17 Victoria St., S.W.
1889 Dec. 3.	DONOHUE, WILLIAM EDWARD, *Major*, Army Ord. Dept. ..	Maryville, Castle Avenue, Dover.
1902 Jan. 14.	DORMAN, WILLIAM STEWART HOBART, B.A., B.E. (*Royal*)	P.W.D., Amballa, Punjab, India.
1902 Feb. 4.	*DORMOR, HENRY DUNCAN ..	H.M. Dockyard, Malta.
1883 Dec. 4.	*DOUGAL, ROBERT	33 Great George Street, S.W.
1894 May 1.	*DOUGLAS, ALEXANDER SHARP, Jun.	McIlwraith & Co., 7 Victoria Street, S.W.
1902 Dec. 2.	*DOUGLAS, EDWARD ALISON ..	Box 115, Roodepoort, Transvaal.
1894 Jan. 9.	*DOUGLAS, GORDON	Minas de Rio Tinto, Huelva, Spain.
1885 May 5.	DOUGLAS, JOHN	24 Esmond Gardens, Bedford Park, W.
1894 May 1.	*DOUGLASS, ALFRED EDWARDS	Waterworks, Paradise Street, Birmingham.
1895 Feb. 5.	DOUGLASS, JAMES ROBERTSON	7 Osborne Place, Dundee.
1895 Feb. 5.	DOUGLASS, WILLIAM LISTON ..	District Offices, Hamilton, N.B.
1891 May 5.	DOVE, JOHN CHARLES	St. Nicholas Ironworks, Carlisle.
✠ 1888 Feb. 7.	DOWDALL, WILLIAM MACDONNELL MITCHELL	Shanghai, China.
1897 Jan. 12.	DOWN, FREDERICK JONATHAN	Glengariff, Milton Road, Harpenden, Herts.
1898 Mar. 1.	DOWNES, JAMES RATHBONE ..	East Surrey Water Co., Redhill.
t ✠ 1887 Feb. 1.	*DOWNES, ROBERT HENRY BURNSIDE	Goldfields Water Supply, Perth, Western Australia.
1901 Apr. 23.	*DOWNIE, ANDREW MARSHALL, B.Sc. (*Glas.*)	4 Strathmore Gardens, Hillhead, Glasgow.

Date of Election.	ASSOCIATE MEMBERS.	
1889 Mar. 5.	DOWNING, ARTHUR JOSEPH, B.A.I. (*Dubl.*)	Old Cabra House, Cabra, Dublin.
1858 Feb. 2.	DOWNING, ROBERT	10 Park Crescent, Oxford.
1902 Apr. 8.	*DOWSON, ERNEST MCLEOD ..	Survey Dept., P.W.D., Cairo.
1897 Feb. 2.	*DOXAT, LOUIS CHARLES JOHN	Irrigation Dept., Colombo, Ceylon
1893 Jan. 10.	DOYLE, KINSLEY DRYDEN, M.A., B.A.I. (*Dubl.*)	18 Park Road, Harlesden, N.W.
1895 Feb. 5.	DRAKE, FRANCIS BRAGG ..	Municipal Engineer, Mowbray, Ca Town, C.C.
1900 Dec. 4.	DREWITT, HARRY WILLIAM ..	John Scott, Dock Extension, Middl brough.
1898 Dec. 6.	*DRIEBERG, JAMES ALFRED GRENIER	P.W.D., Puttalam, Ceylon.
1891 Dec. 1.	DRIFFIELD, EDWARD CARUS ..	Mining & Ry. Co., Mount Ly Tasmania.
1901 Apr. 2.	DRON, ROBERT WILSON	79 West Regent Street, Glasgow.
1902 Apr. 8.	DROUGHT, FREDERICK AINSLIE, B.E. (*Royal*)	Pembrook, Passage West, co. Cor
1903 Apr. 7.	*DROWN, ALFRED ERNEST ..	Rydell, Lanercost Road, Tulse H Park, S.W.
1895 Dec. 3.	*DRUCE, ERNEST HARRY	Box 420, Bulawayo, Rhodesia.
1893 Dec. 5.	*DRUMMOND, HAWTREY MARKS	Cia de Cobres, Calama, Antofagas Chili.
1903 Apr. 7.	*DRUMMOND, PETER, B.Sc. (*Edin.*)	School of Agriculture, Gizeh, Egy
1887 Mar. 1.	*DRURY, ALEXANDER GRAHAM	Rotherhithe Tunnel Works, Sha [well,
1902 Dec. 2.	*DRURY, OSWALD GEORGE COOPER	5 The Grove, Horley, Surrey.
1892 Dec. 6.	*DRURY, RICHARD FREDERICK	Land Registry, 34 Lincoln's I Fields, W.C.
1891 Mar. 3.	*DRYLAND, ALFRED	County Surveyor's Office, Herefor
1888 Mar. 6.	DUARTE, JOÃO RAYMUNDO ..	General Pedra 95, Rio de Janeir
1903 Apr. 7.	*DUCKHAM, FREDERIC WILLIAM	Admiralty Harbour Works, Dove
1890 Dec. 2.	DUCKHAM, HEBER	British Grove, Chiswick, W.
1904 Apr. 12.	*DUDLEY, ROLAND	Harborough Hill, Gretton, Ketteri
1889 Dec. 3.	*DUFF, EDWARD JAMES	Holly Lodge, Cressington Pa Liverpool.
1899 Dec. 5.	DUFF, MATTHEW BUCHANAN ..	42 Frederick Street, Edinburgh.
1889 Feb. 5.	DUFFY, RICHARD	Calle Juncal 2237, Buenos Aires.
1882 Feb. 7.	DUGUID, HARRY GREENFIELD	18 Stanley Place, Pimlico, S.W.
1898 Dec. 6.	*DUKE, AUDLEY MERVYN ..	65 Lansdowne Road, Charlton, S.
1904 Jan. 12.	*DUKE, JOHN REGINALD HARE	Turf Club, Cairo, Egypt.
1890 Dec. 2.	DUNCAN, ALFRED JOHN	Box 14, Bendigo, Victoria.
1891 Jan. 13.	*DUNCAN, ANDREW	New Graving Dock, Queen's Ro Belfast.
1879 May 27.	DUNCAN, EDMUND ALBERT ..	P.W.D., Lahore, Punjab.
1897 Jan. 12.	*DUNCAN, HERBERT ELLIS ..	2 Hartman Place, Bradford.
1896 Dec. 1.	DUNCAN, NORMAN	Municipal Office, Rangoon, Burma
1896 Feb. 4.	DUNKERLEY, *Professor* STANLEY, M.Sc. (*Victoria*)	Royal Naval College, Greenwic S.E.
1876 Jan. 11.	*DUNN, EDWARD ALEXANDER ..	32 Keppel St., Russell Square, W.
1390 May 20.	DUNN, GEORGE BICKHAM ..	Erlemere, Stevenage.
✠ 1885 Jan. 13.	DUNN, PETER LIVINGSTON ..	815 Battery Street, San Francis U.S. (Clutha, San Francisco.)
1883 Mar. 6.	DUNPHY, AUGUSTINE LOUIS ..	Deneside, Foyle Rd, Blackheath, S.
1879 Feb. 4.	*DUNSTON, ROBERT EDWARD ..	State Line and Sullivan Railro Towanda, Pa., U.S.
1887 Dec. 6.	DUQUEMIN, JAMES HENRY ..	Couture Road, Guernsey.
1899 Dec. 5.	*DURHAM, FRANK ROGERS ..	Savignystrasse 43, Frankfurt-am Main.
1900 Dec. 4.	*DURIE, GEORGE ARTHUR ..	P.W.D., Rangoon, Burma. [E.C
1894 Mar. 6.	DURLACHER, ALEXANDER PERCY	33 New Bridge Street, Blackfriar

Date of Election.	ASSOCIATE MEMBERS.	
m ✠ 1893 Dec. 5.	*DURLEY, RICHARD JOHN, B.Sc. (*Lond.*)	McGill University, Montreal, Canada.
1899 Dec. 5.	DURNFORD, HERBERT ST. JOHN	Standard Buildings, City Square Leeds.
1884 May 27.	DUTTON, SAMUEL TELFORD ..	Marl Bank, Worcester.
1893 Jan. 10.	DUXBURY, THOMAS	17 Grosvenor Chambers, Deansgate, Manchester. (Darwinian, Manchester. 1806.)
1887 Dec. 6.	DWYER, FREDERICK LAW, B.A. (*Dubl.*)	Govt. Rys., Cape Town, Cape Colony.
1903 Jan. 13.	*DYER, ARTHUR REGINALD ..	British Westinghouse Co., Norfolk Street, Strand, W.C.
1895 Jan. 8.	*DYKES, ALFRED HERBERT ..	1 Victoria Street, S.W.
✠ 1891 Feb. 3.	*DYMOND, EDMUND ROBERT ..	Vaga House, Hereford.
1890 Feb. 4.	*DYSON, ROBERT CHARLES, F.C.H.	Grindlay, Groom & Co., Bombay.
1891 May 5.	EARL, HENRY DOUGLAS	Oakley, Huyton Park, Liverpool.
1887 Dec. 6.	*EARLY, SYDNEY CHARLES ..	Continental Ice Co., Boulogne-s/Mer.
1880 Apr. 6.	EARNSHAW, JOHN THOMAS ..	Boro' Surveyor, Ashton-under-Lyne.
1883 May 29.	EAST, ROWLAND HARRY	F. C. Puira, Paita, Peru.
1867 Dec. 3.	EASTMAN, THOMAS	Valparaiso, Chile.
1891 Mar. 3.	*EASTON, JAMES RAMMELL ..	42 Gordon Road, Ealing, W.
1867 Dec. 3.	EASTON, JOHN MARSHALL ..	Tordarroch, Helensburgh, N.B.
1896 Dec. 1.	*EASTON, WILLIAM CECIL, B.Sc. (*Glas.*)	Main Drainage Works, Partick, Glasgow.
1902 Dec. 2.	EASTWOOD, WILLIAM	Lindlea, Whitestake, Preston.
1885 Dec. 1.	EATON-SHORE, GEORGE	Borough Surveyor, Crewe.
1878 Feb. 5.	ECKSTEIN, WILLIAM	187 Union Street, Borough, S.E.
1883 Dec. 4.	*EDE, FRANCIS JOSEPH	Silchar, Cachar, India.
1899 Feb. 7.	*EDE, HAINES BREEBAART ..	Whitehall Club, Parliament St., S.W.
1899 Apr. 11.	EDEN, EDGAR MARK	76 Adelaide Road, N.W.
1898 Dec. 6.	*EDGCUMBE, KENELM WILLIAM EDWARD	33 Tedworth Square, Chelsea, S.W.
1889 May 7.	*EDGE, FREDERIC JAMES	City Engineer, Newcastle-on-Tyne.
1895 Dec. 3.	EDGELL, ROBERT GORDON ..	P.W. Office, East Maitland, N.S.W.
m ✠ 1883 May 29.	*EDINGER, WILLIAM HENRY ..	3 Fenchurch Avenue, E.C.
1901 Jan. 8.	EDMONDSON, ALFRED RICHARD, M.Sc. (*Victoria*)	The Oaks, Moss Lane, Timperley.
1895 Feb. 5.	*EDMONDSON, JOHN ALFRED ..	Cowlishaw, Walker & Co., Etruria, Stoke-on-Trent.
1896 Jan. 14.	EDWARDES, CHARLES ARTHUR	Ry. Construction Branch, P.W.D., Sydney, N.S.W.
1883 Feb. 6.	EDWARDS, ANGELO EMANUEL	19 Clifford St., Paisley Rd., Glasgow.
1900 Dec. 4.	EDWARDS, CHARLES WALTER, B.A.I. (*Dubl.*)	Dick, Kerr and Co., 84th Street, Mandalay, Burma.
1902 Mar. 4.	EDWARDS, EDGAR JAMES ..	13 Charing Cross, S.W.
1896 May 19.	EDWARDS, HENRY CLAUDE JOHN	Boro' Engineer's Dept., 346 Kennington Road, S.E.
1895 May 21.	EDWARDS, HERBERT FRANCIS..	104 Stanwell Road, Penarth, Cardiff.
1886 Dec. 7.	*EDWARDS, OSBORNE ANTHONY GEORGE	L. & S.W. Ry., Eastleigh, Hants.
✠ 1887 Dec. 6.	*EDWARDS, WALTER CLEEVE ..	P.W.D., Port Elizabeth, C.C.
1890 Jan. 14.	*EDWARDS, WILLIAM BEN, B.E. (*Royal*)	The Limes, Debenham, Suffolk.
1897 Mar. 2.	*EDWARDS, WILLIAM JAMES ..	Taff Vale Ry., Engineer's Office Cardiff.
1881 May 31.	*EGERTON, ROBERT WALTER ..	c.o. Mrs. Egerton, 17 King's Avenue Ealing, W.
1900 Jan. 9.	*ELCE, WILLIAM HENRY	Boro' Engineer, Bacup.
1880 Dec. 7.	ELDRIDGE, JAMES	Gasworks, Oxford.

Date of Election.	ASSOCIATE MEMBERS.	
1885 Dec. 1.	*ELIOTT, GILBERT FRANCIS ..	Marine Dept., Brisbane, Queensla
1881 Mar. 1.	ELLERY, CHARLES STAFFORD ..	GasL.& C.Co., Up. Bristol Rd., B
1886 Dec. 7.	*ELLIOT, GODFREY TURNBULL	165 Great Dover Street, S.E.
1901 Mar. 5.	ELLIOT, JAMES DUNCAN ..	John Carruthers, 13 Victoria St. S.
1890 May 20.	ELLIOT, MICHAEL	Gunbower West Irrigation Tr Molesworth Chambers, Li Collins St. W., Melbourne, Victo
1894 Feb. 6.	*ELLIOTT, HARRY HORNE ..	Kalabas Kraal, near Malmesbu Cape Colony.
1901 Dec. 3.	ELLIOTT, JOHN ROBERT	Burton Buildings, Parliament Nottingham.
1896 Dec. 1.	*ELLIS, BERTRAM WYBURNE ..	7 Roland Gardens, Kensington, S.
1896 Dec. 1.	*ELLIS, SOMERS HOWE	Tranmere Bay Works, Birkenhe
1904 Apr. 12.	ELLSON, ARTHUR	Globe Works, Grays, Essex.
1901 Dec. 3.	ELLSON, GEORGE	Donnington, Green Lane, N Eltham.
1886 Apr. 6.	ELMORE, JOHN OLIVER SURTEES	State Eng., Kapurthala, Punjab.
1891 May 5.	ELMS, FRANCIS	G.W.Ry., Eng.'s Office, Plymout
1884 May 27.	ELSTON, JOHN	44 Pevensey Road, St. Leona on-Sea.
1884 Jan. 8.	ELSWORTHY, EDWARD HOUTSON	Richardson & Cruddas, Bombay.
1881 Mar. 1.	ELTON, CHARLES TIERNEY ..	J. Higgs, Holsworthy, N. Devon.
1902 Apr. 8.	EMERSON, JOHN WILLIAM SLOAN	13 Earl's Court Square, S.W.
1893 Feb. 7.	EMMOTT, WALTER	1 South Parade, Halifax.
1896 Mar. 3.	*EMTAGE, RAYMOND HOWARD ..	14 James St., Bridgetown, Barbad
1887 Apr. 5.	*ENFIELD, *Viscount*	5 St. James's Square, S.W.
1892 Jan. 12.	*ENGLISH, BERTRAM WILLIAM	63 Overstrand Mansions, Batte Park, S.W.
1889 Feb. 5.	*ENGLISH, FREDERICK HENRY ..	7 Alfred Place West, S. Kensingt S.W.
1892 Dec. 6.	*ENNIS, THOMAS FREDERICK ..	18 Dorlcote Road, Wandsw Common, S.W.
1881 Feb. 1.	ENNOR, CHARLES JOHN	Quinta Pimenta, Foz, Oporto.
1900 Jan. 9.	*ERAUT, WALTER	5 Thornsett Road, Anerley, S.E.
1896 Jan. 14.	*ERICHSEN, FREDERIK OLE ..	Crosby, Lyford Road, Wandsw Common, S.W.
1900 Feb. 6.	ESSEX, ERNEST HENRY	Engr.'s Office, Town Hall, Leyton
1892 Dec. 6.	*ESTCOURT, ARTHUR JOHN ..	London Road Ironworks, Harles Norfolk.
1896 Dec. 1.	*ESTLER, PAUL TRAUGOTT JULIUS	Fairfield House, Old Charlton, S
1851 Apr. 1.	ETTY, THOMAS BODLEY	Belmont Road, Scarborough.
1871 Feb. 7.	EUNSON, JOHN	Gasworks, Northampton.
1898 Apr. 5.	EUSTICE, *Professor* JOHN, B.Sc. (*Lond.*)	Hartley University College, So ampton.
1881 Mar. 1.	EVANS, ARTHUR CLEMENT ..	Thos. Cook & Son, Bombay.
1879 Feb. 4.	EVANS, ARTHUR GEORGE ..	Kington Langley, Chippenham.
1887 Dec. 6.	*EVANS, EDGAR IVOR	District Council, Penarth, Cardi
1892 Mar. 1.	EVANS, EVAN	County Surveyor, Carnarvon.
1892 Mar. 1.	EVANS, WILLIAM	New Walk, Beverley, Yorks.
1897 Jan. 12.	*EVERARD, FRANCIS OVER ..	Belliss & Morcom, Ledsam St Birmingham.
1903 Apr. 7.	EVES, ARTHUR FRANCIS, B.A.I. (*Dubl.*)	Strong and Moore, 36 Mutual Bu ings, Durban, Natal.
✠ 1899 Feb. 7.	EVES, GRAVES WILLIAM, B.A.I. (*Dubl.*)	Jardine, Matheson & Co., Shang
1882 Dec. 5.	EWENS, PAUL	5 Austin Friars, E.C.

Date of Election.	ASSOCIATE MEMBERS.	
1900 Dec. 4.	*Faber, Edward Grey ..	Engineer's Office, London County Council, Spring Gardens, S.W.
1904 Jan. 12.	*Fadelle, Joseph Edward ..	Railway Extension to Bo, Sierra Leone.
1897 Jan. 12.	Fairbairn, Adam Maitland	G. H. Hill, Albert Chambers, Albert Square, Manchester.
1893 Dec. 5.	Fairbairn, Edward Percy ..	26 Clifton Gardens, Folkestone.
1883 May 1.	*Fairbank, Frank Graham ..	Lendal Chambers, York.
1893 Jan. 10.	*Fairgrieve, Edgar Hunter, B.Sc. (*Edin.*)	40 Marchmont Crescent, Edinburgh.
1891 Feb. 3.	*Fairholme, Frederick Charles	Chas. Cammell & Co., Sheffield.
✠ 1886 Apr. 6.	*Fairley, William	69 Victoria Street, S.W.
1904 Feb. 2.	*Falk, Edward	14 South Parade, Southsea.
1892 May 24.	*Farquharson, Thomas, B.Sc. (*Edin.*)	Rosario Nitrate Co., per Gildemeister & Co., Iquique, Chili.
1892 May 3.	*Farr, Clinton Coleridge, D.Sc. (*Adelaide*)	Christchurch, New Zealand.
✠ 1892 Feb. 2.	Farr, William Bean	Netherby, Abington Park Parade, Northampton.
1904 Apr. 12.	*Farrant, Henry, B.A. (*Cantab.*)	44 Emperor's Gate, S.W.
1903 Apr. 7.	Farrar, Harold, M.Sc. (*Victoria*)	Standleigh, Whitefield, Manchester.
l m ✠ 1896 May 19.	*Farrell, Richard Craig ..	70 Wellington Street, Glasgow.
1899 Feb. 7.	Farrington, Thomas Booth	Trinity Square, Llandudno.
1894 May 1.	*Farrington, William	Urban District Council, Woodford.
1904 Jan. 12.	*Farwell, George Douglas ..	11 Laura Place, Bath.
1894 Jan. 9.	Fawcett, Arthur	Old Town Hall, Wakefield.
1889 May 21.	*Fawcus, Alfred	Wartburg Post Office, Natal.
1887 Feb. 1.	*Fearon, Henry Somerville	12 St. Andrew's Square, Surbiton.
1901 Apr. 2.	Fedden, Samuel Edgar	Corporation Electricity Supply Department, Commercial Street, Sheffield.
1900 Apr. 3.	Felkin, Leonard George ..	Topham, Jones & Railton, Gibraltar.
1896 Feb. 4.	Fell, George Noble	43 Gloucester Road, Kew, S.W.
1884 Dec. 2.	Fender, David Thomas ..	14 Hearnville Road, Balham, S.W.
1893 Dec. 5.	Fennelly, Richard	Kilmore, Victoria.
1874 Dec. 1.	*Fenwick, Charles Richard ..	1 Park Place, Leeds.
1884 Dec. 2.	*Ferreira, Eduardo de Moraes Gomes	Pernambuco, Brazil.
1868 May 5.	Ferreira, João Neri	Rio de Janeiro.
1902 Dec. 2.	Ferry, Clement Beaumont	c.o. H. Ferry, 43 Blenheim Road, Bedford Park, W.
1891 Dec. 1.	*Festa, Giulio	11 Cleopatra Street, Alexandria.
1899 Dec. 5.	*Fforde, Francis Creswell ..	Topham, Jones & Railton, Gibraltar.
1893 Mar. 7.	Fidler, Alfred	Boro' Engineer, Northampton.
1900 Feb. 6.	*Field, Michael Birt	8 St. Paul's Rd., Kersal, Manchester.
1904 Jan. 12.	*Field, William Robert, F.C.H.	119 Victoria Street, S.W. (Bandobast, London. Victoria 666.)
1882 Dec. 5.	*Fielden, Edward Brocklehurst	Condover Hall, Shrewsbury.
1894 May 1.	Fielder, Herbert	6 Salisbury Street, S.E.
1892 Feb. 2.	Finch, Alfred Robert ..	Town Hall, Kensington, W.
1902 Dec. 2.	Finch, Ernest Edward ..	Town Hall, Bethnal Green, N.E.
1897 Dec. 7.	Finch, Heneage Wynne, M.A. (*Oxon.*)	New University Club, St. James's Street, S.W.
1888 Jan. 10.	Findlay, George James ..	Glanyrafon, near Wrexham.
1892 Dec. 6.	*Findlay, Robert	Board of Works, The Green, Eltham.
1895 May 21.	*Finlaison, Harry Glen ..	Delta Barrage, Egypt.
1882 May 2.	Finney, James Babbett ..	P.O. Box 16, Georgetown, Demerara.
1886 Feb. 2.	*Finnimore, Benjamin Kington	Kendarea, Darjeeling, India.
1900 Feb. 6.	Firr, Tom Freeman	Survey Dept., Zomba, British Central Africa.

Date of Election.	ASSOCIATE MEMBERS.	
1884 Dec. 2.	*FIRTH, GEORGE SEPTIMUS ..	Arthur's Road, Seapoint, Ca Town, C.C.
1883 Dec. 4.	*FIRTH, SYDNEY	Engineer-in-Chief's Dept., Go Rys., Cape Town, C.C.
1904 Jan. 12.	*FIRTH, WILLIAM JAMES	23 Norman Terrace, Street Lar Roundhay, Leeds.
1886 Mar. 2.	FISH, ROBERT	Newport Villa, York Avenue, Ea Cowes, I.W.
1889 Jan. 8.	FISHER, HENRY BEDWELL ..	L. B. & S. C. Ry., Newhaven.
1885 Dec. 1.	*FISHER, SACKVILLE	
1895 Dec. 3.	FISHER, WILLIAM CLARK ..	24 Albany Road, Ealing, W.
1891 Apr. 7.	*FISHER, WILLIAM DIXON ..	Gresham House, Singapore, S.S.
1890 Feb. 4.	*FITT, JOHN EDWARD	P.W.D., Cape Town, C.C.
1889 May 7.	FITZGERALD, GERALD	Levin & Co., Wellington, N.Z.
1876 Dec. 5.	*FITZGERALD, MAURICE FREDERICK, B.A. (*Dubl.*)	32 Eglantine Avenue, Belfast.
1890 Dec. 2.	FITZ-GERALD, ROBERT DAVID	Roads and Bridges Dept., Sydne [N.S.W
1898 Dec. 6.	FITZGIBBON, PHILIP JOHN ..	Belgaum, India.
1886 Dec. 7.	FITZ-PATRICK, ROBERT PEERS	Local Government Board, Dublin.
1893 May 16.	FLACH, JAMES	Goldfields, Donnybrook, W. Australi
1889 Dec. 3.	*FLAVELLE, ALBERT EDWARD ..	Lucerne, Cowles Road, Mosma New South Wales.
1890 Dec. 2.	FLAVIN, WILLIAM RICHARD ..	Jackson House, Jackson Ghat Stree Calcutta.
1894 Jan. 9.	FLEMING, GEORGE EDWARD ..	Dewrance & Co., 79 West Rege Street, Glasgow.
1904 Jan. 12.	FLEMING, SAMUEL HENRY, B.E., B.A. (*Royal*)	Crookland's Inn, Milnthorpe.
1894 May 1.	*FLETCHER, BERNARD MORLEY	20 Victoria Street, S.W. (Agonium London. Westminster 5085.)
1891 May 5.	*FLETCHER, GEORGE EDWIN ..	77 King Street, Manchester.
1893 May 2.	*FLETCHER, HENRY LAVINGTON	Murdoch & Templeton, Mansoural Egypt.
1897 Dec. 7.	*FLETCHER, HERBERT PHILLIPS	29 New Bridge Street, E.C.
1887 May 24.	FLETCHER, JOHN	Boro' Eng., Durban, Natal.
✠ 1886 Feb. 2.	FLETCHER, JOHN WILLIAM ..	The Homestead, Cale Green, Stock port.
1892 Dec. 6.	*FLETCHER, PATRICK	Bulawayo, Matabeleland.
1891 Dec. 1.	*FLETCHER, ROBERT ALEXANDER	Bulawayo, Matabeleland.
1892 Dec. 6.	FLETCHER, WILLIAM WELLESLEY POLE	19 Upper Phillimore Place, Kensing ton, W.
1899 Apr. 11.	*FLOOD, JOHN GARNAR, B.A. (*Cantab.*)	Ibstock, near Leicester.
1897 Apr. 6.	*FLOWER, ERNEST HUBERT ..	47 Drummond Road, Agra, India.
1894 Dec. 4.	FLOWER, THOMAS JAMES MOSS-	Carlton Chambers, Baldwin St., Bris tol. (Moss-Flower, Bristol, 756.
1901 Dec. 3.	FOLEY, JOHN	24 Torrens Square, Stratford, E.
1904 Apr. 19.	FOLK, SAMUEL MARK	73 Park Road, Regent's Park, N.W
1887 Mar. 1.	FOOT, FREDERICK ROBERT ..	New Fastnet Works, Rock Island, Skibbereen, co. Cork.
1888 Mar. 6.	*FORBES, ANDREW	136 Otley Road, Leeds.
1896 Mar. 3.	*FORBES, HENRY KEITH	Long Newton Reservoir, Darlington.
1873 May 6.	FORD, ARCHIBALD HENRY ..	11 High Street, Portsmouth.
1892 May 24.	*FORD, CHARLES FREDERICK VERNON	Marehay Main Colliery, Ripley, Derby.
1883 May 29.	*FORD, HENRY WALTER	Calle Constitucion 1464, Buenos Aires
1889 Jan. 8.	*FORD, HUGO ROBERT	Estacion Haedo, F. C. Oeste, Buenos Aires.
1891 Dec. 1.	FORD, JOHN CUNNINGHAM ..	Cooke & Sons, 14 Great Chapel Street, Westminster, S.W.
1894 Mar. 6.	*FORD, THOMAS WHARTON ..	9 Bridge Street, Westminster, S.W.

	Date of Election.	ASSOCIATE MEMBERS.	
	1897 Jan. 12.	Forde, Henry Bligh	Norddeutsche Seekabelwerke, Nordenhamm-an-der Weser, Germany.
	1890 Apr. 1.	Forder, Walter George	107 High Road, Lee, S.E.
	1894 Dec. 4.	Forrest, John Charles	Holly Bank Colliery, Essington, Wolverhampton.
✠	1896 Apr. 14.	*Forrest, William Robertson Lidderdale	7 The Sanctuary, Westminster, S.W.
	1896 Mar. 3.	*Forrester, Arthur Livesey	Lea Cottage, Malmesbury, Wilts.
✠	1894 May 22.	Forster, Charles Edward, B.A. (*Sydney*)	Colonial Sugar Refining Co., Sydney, N.S.W.
	1882 Dec. 5.	Foster, Edward William Perceval, C.M.G.	P.W.D., Cairo.
	1890 Dec. 2.	Foster, Frank	F. C. Oeste, Once, Buenos Aires.
	1891 Dec. 1.	*Foster, Henry Llewellyn Thomas	M. Longridge, 12 King Street, Manchester.
	1890 Feb. 4.	Fothergill, John Reed	1 Bathgate Terrace, West Hartlepool.
	1901 Apr. 2.	Foulis, William Ainslie	Tyne Improvement Commission, Newcastle-on-Tyne.
	1886 Mar. 2.	Fowle, Fulwar Craven	Nagpur, C.P., India.
	1902 Jan. 14.	*Fowler, Cecil Arthur, B.A.I. (*Dubl.*)	1 Newtown Villas, Waterford.
m ✠	1896 Dec. 1.	*Fowler, Henry	122 Rose Hill Street, Derby.
	1902 Dec. 2.	Fowlds, Walter	Boro' Engineer's Office, Keighley.
	1904 Mar. 1.	*Fox, Alfred, Jun.	Senor J. E. Harmsen, Arequipa, Peru.
f m ✠	1901 Mar. 5.	*Fox, Charles Beresford, M.A. (*Cantab.*)	Victoria Falls Bridge, Livingstone, Rhodesia.
✠	1890 Feb. 4.	*Fox, Guilherme Henrique	States Ry., Kajang, Malay, S.S.
	1893 Jan. 10.	*Fox, John Richard Stratford	F. C. Rosario, Calle Bartolome Mitre 299, Buenos Aires.
	1904 Apr. 12.	*Fox, Senior Frederick Leopold	Town Hall, Newport, Mon.
	1897 Dec. 7.	*Foy, Ernest Rudolph	Chenâb Canal, Lyallpore, India.
	1884 Dec. 6.	Fränckel, Edward	Atlas Works, Stockholm.
	1879 Feb. 4.	Francken, William Augustus	c.o. Grindlay & Co., Parliament Street, S.W.
	1891 Apr. 7.	Franklin, Luke, B.E. (*Queen's*)	Mount Road, Fleetwood.
	1901 Dec. 3.	*Franks, Charles Foard	South Metropolitan Gas Company, 70 Bankside, S.E.
	1894 Jan. 9.	*Franks, Thomas William	Seveirg Buildings, Lewes.
	1892 May 3.	Fraser, Alexander Orme	C. P. Green, Beresford House, Great Malvern.
	1881 Dec. 6.	*Fraser, Ernest Gordon	Staunton House, Staunton, Coleford, Glos.
	1903 Apr. 7.	Fraser, Thomas	Govt. Rys., Engineer's Camp, George, Cape Colony.
	1904 Apr. 12.	Fraser, William Alexander	1 Ogilvie Terrace, Merchiston, Edinburgh.
	1873 May 20.	Fraser, William John	121 Adelaide Rd., Hampstead, N.W.
	1895 Dec. 3.	Frech, Alfred Sigismund	Engineer's Office, Victoria Docks, E.
	1877 Dec. 4.	Freeman, Henry Somerson	Cormongers, Nutfield.
t ✠	1895 Apr. 2.	*Frere, Frank Horace	Eng.'s Office, Midland Ry., Derby.
	1901 Apr. 2.	*Freund, George John, Jun.	Lancaster House, Dacres Road, Forest Hill, S.E.
	1896 Dec. 1.	Frew, Alexander	140 West George Street, Glasgow.
	1890 Dec. 2.	Frew, Robert Dixon Alison	Chelmer, near Brisbane, Queensland.
	1901 Feb. 5.	*Friedberger, Maurice Bryham	Nedderton, near Newcastle-on-Tyne.
	1891 Apr. 7.	*Friederichs, Herbert Ferdinand	Electric Light Station, Burn Road, West Hartlepool.
	1902 Dec. 2.	Friel, William	Chamber of Commerce Buildings, Waterford.
	1888 Feb. 7.	*Frobisher, Edward	Urban District Council, Fleetwood.
	1884 Dec. 2.	Froggatt, William	Chapeltown, Sheffield.
	1886 Dec. 7.	Fry, William Henry	9 High Street, Gosport.

	Date of Election.	ASSOCIATE MEMBERS.	
	1893 Dec. 5.	*FUHR, HENRY HANNAY	P.W.D., King William's Town, (
	1887 Dec. 6.	FUJIKURA, KENTATSU	4 Atagomachi Sanchome, Sh Tokio, Japan.
	1890 Jan. 14.	FULTON, DAVID	1 Garden Court, Temple, E.C.
	1893 Dec. 5.	*FURNESS, GEORGE JAMES ..	Knowles Tower, Roundwood R Willesden, N.W.
	1898 Dec. 6.	*FURNIVALL, FRANK..	King, King & Co., Bombay.
	1900 Dec. 4.	GABBETT, EDWARD	P.W.D., Maymyo, Burma.
	1900 Apr. 3.	GADSBY, DAVID JOHNSON ..	12 Cambridge Road, Hove, Sus
	1888 Jan. 10.	GAFFNEY, FRANCIS SEBASTIAN BURKE	Deputy Colonial Engineer, Pena S.S.
	1896 May 19.	GAFFNEY, STAFFORD, M.A.I. (*Dubl.*)	Cork, Blackrock & Passage I Monkstown, co. Cork.
	1892 Dec. 6.	*GAGE, JOHN FRANKLIN	190 Fordwych Road, Cricklew N.W.
	1900 Feb. 6.	GAILEY, THOMAS ANDREW, B.E., B.A. (*Royal*)	Woodleigh Terrace, Londonderr
m	1871 Mar. 7.	*GAINSFORD, THOMAS ROBERT..	Woodthorpe Hall, near Sheffield.
	1877 May 29.	GALBRAITH, JOHN, M.A. (*Toronto*)	School of Practical Science, Toro
m ✠	1894 Dec. 4.	*GALE, ARTHUR ROBERT	96 Midland Road, Bedford.
m	1889 May 21.	*GALE, CHARLES HENRY	P.W.D., Hong Kong.
	1895 May 21.	GALE, WILLIAM WILLIS ..	Urban District Council, Carshalt
	1891 Mar. 3.	*GALES, ROBERT RICHARD, F.C.H.,	King, King & Co., Bombay.
✠	1884 May 27.	GALLON, WILLIAM	Vestry Hall, Upper St., Islington.
	1877 Dec. 4.	*GALLOWAY, THOMAS LINDSAY, M.A. (*Glas.*)..	175 West George Street, Glasgow
	1880 Dec. 7.	GAMBLE, SIDNEY GOMPERTZ ..	Fire Brigade, Southwark, S.E.
	1892 Dec. 6.	GANDON, JOHN..	Ottoman Gas Company, Smyrna.
	1889 Mar. 5.	*GARBUTT, MATTHEW	Bishop's Road Station, W.
	1894 Dec. 4.	*GARDNER, JOHN WISHART FAIRLIE	15 Waverley Gardens, Crossmyl Glasgow.
	1897 Dec. 7.	*GARFIELD, JOSEPH	Thackley, Bradford.
	1890 Apr. 1.	*GARLAND, ERNEST TALBOT COPE	Ipoh, Perak, Malay, S.S.
	1899 Dec. 5.	*GARNETT, SYDNEY HAROLD ..	Cardross, Dumbartonshire.
	1900 Apr. 3.	GARRARD, GEORGE	Waterworks, Small Street, Bristo
	1891 May 5.	*GARRARD, JOHN JERVIS	119 Church St., Maritzburg, Nat
✠	1895 Apr. 2.	GARRATT, HERBERT ALFRED ..	Northern Polytechnic Institute, H loway Rd., N.
	1895 Feb. 5.	*GARRETT, FRANK, Jun.	Leiston Works, Suffolk.
	1902 Dec. 2.	GARRETT, FREDERICK MORTON	Box 271, Bloemfontein, Ora River Colony.
	1890 Dec. 2.	GARRETT, HENRY AUGUSTUS ..	Town Surveyor, Torquay.
	1904 Apr. 12.	GARROD, CHARLES, B.Sc. (*Lond.*)	7 Jenner Road, Stoke Newingto
	1896 Dec. 1.	GARROD, JOHN REBBECK ..	F.C.E.R., Parana, Entre I Argentina.
	1895 Dec. 3.	GARSIDE, EDWARD	Town Hall Chambers, Ashton-u Lyne.
	1891 Dec. 1.	GARSON, GEORGE, B.Sc. (*Edin.*)	Victorian Water Supply, Melbo Victoria.
	1892 May 24.	GARTHWAITE, JOHN GEORGE ..	Engineer's Office, Guildhall, E
	1902 Jan. 14.	*GARVIE, ROBERT HALLEY ..	Docks, Trafford Road, Salford.
	1892 Jan. 12.	GASKELL, JOHN BERRIDGE ..	Dock & Ry. Co., Milford Haven.
	1899 Apr. 11.	*GASKIN, FREDERIC WILLIAM	Water Engineer's Dept., Liverp
	1894 Dec. 4.	GATEHOUSE, TOM ERNEST ..	60 Gresham Road, Brixton, S.W.
	1891 Feb. 3.	*GATES, CHASEMORE PHILIP ..	5 Lawn Road Villas, Doncaster.
	1887 Apr. 5.	GATT, LORENZO	10 Strada Seconda, Floriana, M
	1900 Feb. 6.	*GAVIN, JOSEPH MERRICKS ..	65 South Hill Park, Hamp N.W.

Date of Election.	ASSOCIATE MEMBERS.	
1903 Apr. 7.	GAZE, HARRY PHILIP	Central Electric Supply Co., Grove Road, St. John's Wood, N.W.
1900 Apr. 3.	*GEDYE, NICHOLAS GEORGE, B.Sc. (*Birmingham*)	15 Victoria Street, Westminster, S.W.
1893 Mar. 7.	*GELSTON, ROBERT	74 George Street, Limerick.
1882 Dec. 5.	*GEORGE, DUNCAN	King, King & Co., Bombay.
1894 Mar. 6.	GERRAND, DAVID	Box 3712, Johannesburg, Transvaal.
1899 Dec. 5.	GERTNER, ALBERT WILLIAM .	State Rys., Victoria Malleco, Chile.
✠ 1890 Dec. 2.	GHOSH, JOGINDRA NATH ..	P.W.D., Barisal, Bengal.
1897 Apr. 6.	*GIBB, ALEXANDER	Contractor's Office, New Dock Works, Ipswich.
1866 Feb. 6.	GIBB, EASTON	Haversham Grange, Twickenham.
1904 Apr. 19.	GIBBINGS, ALFRED HORSWILL	Lynton, Heaton Norris, Stockport.
1892 Feb. 2.	GIBBINS, WILLIAM DICKINS ..	63 Victoria Road, Northampton.
1874 May 5.	*GIBBONS, CHARLES PRESTON ..	T. Docwra & Son, Ball's Pond, N.
1889 Feb. 5.	GIBBONS, GEORGE BENJAMIN ALBERT	The Limes, Pedmore.
1902 Apr. 8.	GIBBS, ALECK ROBERT	35 Medora Road, Brixton Hill, S.W.
m ✠ 1891 Dec. 1.	*GIBBS, LAWRENCE	Denison, Ram & Gibbs, Hong Kong.
1902 Dec. 2.	*GIBSON, ALEXANDER JAMES ..	Railway Construction Branch, P.W.D., Sydney, N.S.W.
1900 Apr. 3.	GIBSON, GEORGE HENRY	246 Bath Street, Glasgow.
1890 Jan. 14.	*GIBSON, NORMAN WALTER JOHN	7 Royal Arsenal, Woolwich.
1900 Dec. 4.	*GIBSON, RALPH ERNEST ..	Gasworks, Huddersfield.
1899 Apr. 11.	GIBSON, THOMAS SYDNEY FLETCHER	Gasworks, 709 Old Kent Rd., S.E.
1885 Dec. 1.	*GIFFORD, EDWARD	Mrs. Gill, Fleet, near Weymouth.
1890 Jan. 14.	*GIFFORD, HERBERT JAMES ..	
1895 Feb. 5.	*GILBERT, THOMAS STEPHEN, B.E. (*Royal*)	Harbour Office, Belfast.
1885 Dec. 1.	*GILES, WALTER	H. S. King & Co., Pall Mall, S.W.
1883 Dec. 4.	GILL, ALBERT AUGUSTUS ..	35 Commercial Road, Pimlico, S.W.
1901 Apr. 2.	GILL, HENRY DUDLEY	Hornchurch Hall, Hornchurch, Essex.
1886 May 4.	GILL, JOHN	Lea Hurst, Bangor.
1888 Apr. 10.	GILL, JOHN	Imperial Road, Fulham, S.W.
✠ 1878 Feb. 5.	*GILL, JOHN CHARLES	Municipal Offices, Peterboro'.
1884 Mar. 4.	*GILL, LEONARD ALDRIDGE ..	Ingleside, Montague Rd., Ealing, W.
1886 Dec. 7.	GILLESPIE, JOHN	Govt. Rys., Engineer's Dept., Cape Town, C.C.
1889 Dec. 3.	GILLIES, JAMES DOUGLAS ..	Greymouth, New Zealand.
1889 Dec. 3.	*GILLINGHAM, ALFRED JOHN ..	San Isidro 374, San Martin, Provincia de Buenos Aires, Argentina.
1894 May 1.	*GILL-JENKINS, DANIEL	Coromandel Gold Mining Co., Mysore, India.
1895 Jan. 8.	GILLMAN, GUSTAVE	Gt. Southern Ry., Aguilas, Spain.
1898 Dec. 6.	GILMOUR, DAVID	Box 231, Johannesburg, Transvaal.
1891 Dec. 1.	GILMOUR, ROBERT	122 Wellington Street, Glasgow.
1896 Dec. 1.	*GIVEN, ERNEST CRANSTON ..	4 Hargreaves Road Liverpool. (Given, Liverpool. Garston 183).
1900 Mar. 6.	GLASS, SYDNEY NEWTON ..	16 Ravenscroft Road, Chiswick, W.
✠ 1896 Jan. 14.	*GLOVER, GEORGE TERTIUS ..	N.E. Ry., Carriage Dept., Heaton-on-Tyne.
1887 Dec. 6.	GLOVER, RALPH STEPHEN, M.E. (*Queen's*)	Midland Ry., Betwa, India.
1891 Dec. 1.	*GLOVER, THOMAS	Bengal Iron Co., Barakur, Bengal.
✠ 1888 Dec. 4.	*GLOYNE, ROBERT MAYNARD ..	30 Cumberland Road, Kew Gardens, S.W.
1885 Feb. 3.	GODAI, RIYOSAKU	5 Kitamachi, Ushigome Ku, Tokio, Japan.
1891 Mar. 3.	GODFREY, ARTHUR HILL ..	
1895 May 21.	*GODFREY, BERNARD	Bramley, Rotherham.

Date of Election.	ASSOCIATE MEMBERS.	
m ✠ 1899 Dec. 5.	*GODFREY, CHARLES HENRY ..	Municipal Offices, Shaghai.
1897 Dec. 7.	*GODFREY, FREDERICK WILLIAM	De Aar-Prieska Ry., De Aar, Ca Colony.
1897 Mar. 2.	*GODFREY, GEORGE COCHRANE, B.A. (*Cantab.*)	Bengal-Nagpur Railway, 17 Gard Reach Road, Calcutta.
1899 Dec. 5.	GODFREY, JOHN BRETON, B.E. (*Calcutta*)	W. Watson & Co., Bombay.
✠ 1888 Apr. 10.	GODFREY, ROBERT	Silver How, Alne, York.
1900 Apr. 3.	*GONSALVES, GEORGE	C. H. Walker & Co., 660 Commerci Road, Limehouse, E.
1889 Mar. 5.	*GOOCH, HENRY JESSE	Chelsea Waterworks, Commerci Road, Pimlico, S.W. [va
1899 Dec. 5.	GOOD, HARRY	Town Engineer, Boksburg. Tran
1890 Mar. 4.	*GOODALL, CLARENCE NOËL ..	Robert Stephenson & Co., Darlin ton.
1886 Apr. 6.	*GOODALL, THOMAS EDWARD ..	c.o. Mrs. Goodall, 57 Fitzroy R Regent's Park, N.W.
1878 Feb. 5.	*GOODFELLOW, ARTHUR TRETH-OWAN	H. S. King & Co., 65 Cornhill, E.C
1899 Dec. 5.	*GOODMAN, GEORGE SMITH ..	Mrs. Reeve, 3 Alton Terrace, Mu ley, Plymouth.
1894 Feb. 6.	*GOODMAN, JAMES	Grand Junction Waterworks, Bren ford, W.
1894 Dec. 4.	*GOODMAN, RICHARD	51 Cambridge Road, Chiswick, W.
1889 Apr. 2.	GOODYEAR, HERBERT	Boro' Engineer, Colchester.
1890 Dec. 2.	GORDON, CHARLES GRIMSTON ..	c/o Royal Colonial Institut Northumberland Avenue, W.C.
1904 Mar. 1.	*GORDON, GEORGE FRANCIS CARTER, M.A. (*Cantab.*) ..	Asansol, East Indian Railwa India.
1888 Apr. 10.	GORDON, HENRY ANDREW ..	Bank of New Zealand Building Queen Street, Auckland, N.Z.
1899 Feb. 7.	*GORDON, HENRY HERMAN, B.A. (*Lond.*)	2 Great Prescott Street, E.
1894 Dec. 4.	GORDON, JOHN	Burgh Surveyor's Office, Aberdeen
1897 Apr. 6.	*GORE, WILLIAM	44 Inman Road, Harlesden, N.W.
1887 May 3.	GOSLETT, CHARLES ALFRED ..	1733 Euterpe St., New Orleans, U.
1899 Apr. 11.	GOSTWYCK, HUMPHREY HARFORD GOSTWYCK	Engineer's Office, E. I. Ry., Ca cutta.
1898 Mar. 1.	GOTT, CHARLES HENRY	8 Charles Street, Bradford.
1884 Dec. 2.	*GOTTO, PERCY MURLY	228 Dashwood House, New Broa Street, E.C. [N.V
1895 Jan. 8.	GOTTO, PETER	West Heath House, Hampstea
1904 Jan. 12.	GOULD, HENRY	24 Church Street, Kingston, Jamaic
1892 Jan. 12.	GOULDEN, THOMAS	Gasworks, Beckton, E.
✠ 1891 Feb. 3.	GOUMENT, CHARLES ERNEST VERE	P.W.D., Lahore, Punjab.
1902 Apr. 8.	GOW, WILLIAM JAMES	Technical Institute, Saltram Cre cent, Maida Hill, W.
1884 May 27.	GRAÇA, JOAO CORDEIRO DA ..	P.O. Box 566, Rio de Janeiro.
1878 Feb. 5.	GRAFTON, ALEXANDER	Vulcan Works, Bedford. (Grafto Bedford.)
1900 Feb. 6.	*GRAHAM, ALFRED HENRY IRVINE	12 Thorncliffe Grove, Manchester.
1900 Dec. 4.	*GRAHAM, DONALD CHARLES	Cotswold, Lansdowne Road, Wimble don, S.W.
1874 Apr. 14.	GRAHAM, FRANCIS EDMOND ..	23 Cork Street, W.
1893 Apr. 11.	GRAHAM, MAURICE	Summerhill, Apperley Bridge, York
1877 May 1.	GRANT, ALEXANDER	Maryhill, Inverness.
1857 Feb. 3.	GRANT, CHARLES HENRY ..	Addlestone, Hobart, Tasmania.
1904 Jan. 12.	GRANT, CHARLES JAMES, B.C.E (*Melbourne*)	Mildura, Victoria.
1883 Dec. 4.	GRANT, ROBERT CAMPBELL ..	Hale Edge, South Nutfield, Surrey

Date of Election.	ASSOCIATE MEMBERS.	
1898 Feb. 1.	GRANT-BROWNING, JOHN ..	East London Waterworks, Lea Bridge, Clapton, N.E.
1870 Apr. 5.	*GRAVELL, DAVID	6 Queen Anne's Gate, S.W. (P.O. Telephone—Victoria 481.)
✠ 1898 Dec. 6.	*GRAY, ANDREW	Marconi Wireless Telegraph Co., 18 Finch Lane, E.C.
1888 May 15.	GRAY, CHRISTIAN HAMILTON ..	Telegraph Works, Silvertown, E.
1897 Apr. 6.	GRAY, FRANK JAMES	Land Registry, 4 Clement's Inn, W.C.
1896 May 5.	GRAY, GEORGE DAVID, B.A.I. (*Dubl.*)	Eng.'s Office, City Hall, Dublin.
1892 Jan. 12.	*GRAY, HENRY HOLMES	Aldermaston, near Reading.
1897 Mar. 2.	*GRAY, ROBERT BRUCE MCGREGOR	Gowthorpe, Selby.
1891 Apr. 7.	GRAY, WILLIAM	44 Broad Street, Birmingham.
1888 May 15.	GRAY, WILLIAM ERNEST ..	Telegraph Works, Silvertown, E.
1891 May 5.	GRAY, WILLIAM WYTHERS ..	4 Benet Street, Cambridge.
1885 May 19.	GREATHEAD, WALTER HORATIO	Box 4751, Johannesburg, Transvaal.
1890 Dec. 2.	*GREATOREX, ALBERT DANIEL	Boro' Engineer, West Bromwich.
1888 Apr. 10.	GREEN, EDWARD BAKER . ..	13 Queen's Road, Erith.
1898 Apr. 5.	*GREEN, FREDERICK DAVIES ..	Glengali, Wanstead, E.
1887 Apr. 5.	*GREEN, GEORGE	Town Hall, Wolverhampton.
1891 Dec. 1.	*GREEN, GEORGE WILLIAM ..	12 Mortlake Road, Kew.
1879 Apr. 1.	GREEN, HENRY	Gas Company, Preston.
1889 Apr. 2.	*GREEN, ROBERT	37 Waterloo Street, Birmingham. (Pritchard, Birmingham. 4450.)
1895 May 21.	*GREENE, LOUIS	East Indian Ry., Calcutta.
1885 Mar. 3.	GREENHILL, FREDERICK MORRIS	1 Church Road, Penarth, Cardiff.
1865 May 2.	GREENHILL, THOMAS ARTHUR	Santa Teresa 9, Madrid.
1897 Feb. 2.	*GREENHOUGH, FREDERICK HARRY	New Breakwaters, Grand Harbour, Malta.
1884 Apr. 1.	GREENLEES, ARCHIBALD	The Elms, Park Lane, Tottenham, N.
1893 Dec. 5.	GREENSHIELDS, NORMAN ..	Borough Surveyor, Bedford.
1899 Dec. 5.	GREENSHIELDS, ROBERT PADMORE	Hydraulic Power Co., 99 Queen St., Melbourne, Victoria.
1891 Dec. 1.	GREENWELL, ALLAN	30 Furnival Street, Holborn, E.C.
1893 Dec. 5.	GREENWOOD, CLAUDE	B. Greenwood, Ossett, Yorks.
1902 Dec. 2.	GREENWOOD, JOSEPH PARKER	Borough Surveyor's Office, Burnley.
1876 Apr. 4.	GREGORY, CHARLES CURRIE .	Antigonish, Nova Scotia.
1899 Dec. 5.	GREGORY, GEORGE MESROPE ..	1 Park Lane, Calcutta.
1892 Feb. 2.	*GREGSON, GEORGE LEOPOLD ..	Blackfalds, Albert Road, Wolverhampton.
1889 Feb. 5.	*GREGSON, HERBERT BOYS ..	25 Trewsbury Road, Sydenham, S.E.
1890 May 6.	GREGSON, JOHN	Westwood, Padiham, Lancs.
1886 Dec. 7.	GREIG, ALFRED BURNESS ..	
✠ 1875 Apr. 6.	GREIG, ANDREW	3 Duntrune Terrace, Broughty Ferry, N.B.
1903 Jan. 13.	*GREIG, BENJAMIN WILLIAM PATON	c.o. Lowdon National Bank, El Paso, Texas, U.S.
1902 Apr. 8.	GREIG, JAMES RENNIE	117 Bedford Court Mansions, W.C.
1904 Apr. 12.	GREIG, JOHN MARTIN MACFIE	Drainage Works, Partick, Glasgow.
1898 Apr. 5.	GREY, WILLIAM CHARLES ..	Ry. Construction Branch, P.W.D., Sydney, N.S.W.
1880 Apr. 6.	*GRIERSON, CHARLES JAMES ..	4 St. Mary's Villas, Warwick Road, Ealing, W.
1904 Jan. 12.	GRIEVE, JAMES HENRY, B.Sc. (*Glas.*)	El Damer, Sudan.
1893 Dec. 5.	GRIFFIN, ALBERT EDWIN ..	Butterfield and Swire, Hong Kong.
1881 Dec. 6.	GRIFFIN, BEVERLEY	Priory Lodge, Sydenham Road, Guildford.
1901 Jan. 8.	*GRIFFITH, CHARLES LEOPOLD TROYTE	Selworthy, College Road, Harrow-on-the-Hill.
1902 Apr. 8.	*GRIFFITH, JOHN WILLIAM, M.A., B.A.I. (*Dubl.*)	Engineer's Office, Port and Docks Board, East Wall, Dublin.

Date of Election.		ASSOCIATE MEMBERS.	
	1893 Dec. 5.	*Griffiths, André Pierre, B.Sc. (*Paris*)	6 Rue de l'Oranger, Dieppe.
	1894 Dec. 4.	Griffiths, Harry Denis ..	Box 2146, Johannesburg, Transvaa
W O ✠	1874 Jan. 13.	*Griffiths, John Alfred, B.Sc. (*Victoria*)	Patent Office, Brisbane, Queenslan
	1887 Apr. 5.	Griffiths, Walter George	Rhymney Ry., Cardiff.
	1878 May 28.	Griffiths, William	61 Sinclair Road, Kensington, W.
	1890 Apr. 1.	*Grimes, Arthur John Lund	Indian Telegraph Dept., Bombay.
	1886 Dec. 7.	*Grimsley, Samuel Slater ..	District Council, Hendon, N.W.
	1898 Dec. 6.	Grimshaw, Conway Osborne	57 St. George's Square, S.W.
	1897 Apr. 6.	*Grimshaw, Frederick Henry	Urban District Council, Atherto Manchester.
	1879 Mar. 4.	Grimshaw, James Robert, B.A.I. (*Dubl.*)	London County Council, Spri Gardens, S.W.
	1902 Dec. 2.	*Grimston, Francis Sylvester	4 Glenluce Road, Blackheath, S.E
	1886 Dec. 7.	*Gritton, Charles Edward..	Dock House, Billiter Street, E. (Galvanical, London.)
	1879 Apr. 1.	*Grose, Arthur	Misterton, East Park Parade, Nort ampton.
	1850 Dec. 3.	Grove, Edmund	Norlington, Preston, Brighton.
	1899 Apr. 11.	*Grove, Edward Long	Kuching, Sarawak, Borneo.
	1895 Apr. 2.	*Grover, Frederick	Greek Street Chambers, Leeds.
	1877 May 29.	Groves, Leonard	Carisbrooke, near Newport, I.W.
	1889 Jan. 8.	Grover, Levy John	Crinan Canal, Ardrishaig, N.B.
	1888 Feb. 7.	Grunwell, Hartley	Isles Crane Works, Stanningle Leeds.(c/o Isles,Stanningley. 4
	1896 Dec. 1.	Guadagni, Bernardo	51 Via Faenza, Florence, Italy.
	1894 Feb. 6.	*Guest, Richard	North British Loco. Co., At Works, Springburn, Glasgow.
	1878 Feb. 5.	*Guillemard, Arthur Franklin, B.A. (*Oxon.*)	Arica Ry., Tacna, Chile.
	1884 Jan. 8.	*Guinness, Arthur Percy ..	5 The Drive, Loughton, Essex.
	1894 Dec. 4.	Guinness, Henry Seymour ..	Evesham, Blackrock, co. Dublin.
	1896 Dec. 1.	*Gullan, Hector Freeman ..	Supt. of Works, Town Hall Stre Belfast.
	1904 Jan. 12.	*Gulland, Charles	P.W.D., Bombay.
	1882 Apr. 4.	Gumbley, William	Box 2332, Johannesburg, Transva
	1889 Dec. 3.	Gunyon, Charles James ..	30 Clarence Road, Wood Green, N
	1880 May 25.	*Gunyon, Thomas Percy ..	Chislehurst, Kent.
	1891 Dec. 1.	*Guyatt, Thomas Alexander	Gasworks, Ely.
	1902 Apr. 8.	Guyatt, William James ..	Dorman & Long, Constructio Dept., Middlesbrough.
	1885 Dec. 1.	Hadfield, Frederick Joseph	Manor House, Ringsfield, Beccles
	1901 Apr. 2.	*Hadow, Frederick Austen ..	King, King & Co., Bombay.
	1892 Dec. 6.	Hahn, Daniel Meinerts ..	Port of Spain, Trinidad.
	1885 Dec. 1.	Haigh, Jonathan	Town Hall, Abergavenny.
✠	1902 Apr. 8.	Haigh, William Henry ..	Borough Engineer's Office, Cardif
	1879 May 27.	Haines, Joseph Richard ..	Adderley Green Colliery, Stoke-o Trent.
	1895 Mar. 5.	Halden, George Mason ..	G. N. & City Ry., Poole Street, Ne North Road, N.
	1889 Mar. 5.	Hall, Albert Francis ..	The G. F. Blake Mfg. Co., Third S East Cambridge, Mass., U.S.
	1890 Apr. 1.	Hall, Carl	Durban Club, Durban, Natal.
	1892 Dec. 6.	Hall, Harry	113 Fawnbrake Avenue, Herne Hi S.E.
	1899 Apr. 11.	Hall, John Willim	Athenaeum Chambers, Birmingha
	1894 Dec. 4.	*Hall, Leonard George ..	Gas and Waterworks, Rhyl.

	Date of Election.	ASSOCIATE MEMBERS.	
	1894 Feb. 6.	HALL, THOMAS ANDREW, B.E. (*Royal*)	Lough Swilly Ry., Pennyburn, Londonderry.
	1890 Feb. 4.	HALL, THOMAS BERNARD ..	119 Colmore Row, Birmingham. (Tamar, Birmingham.)
	1891 Jan. 13.	HALL, WATKIN	Local Board, Gt. Crosby, Liverpool.
m	1900 Dec. 4.	*HALL, WILFRED, M.A. (*Cantab.*)	Dilston Hall, Corbridge-on-Tyne.
	1897 Dec. 7.	HALL, WILLIAM	Grindlay & Co., 54 Parliament Street, S.W.
	1885 Dec. 1.	HALLER, JAMES CRACROFT ..	Corporation Chambers, Dewsbury.
	1886 Mar. 2.	HALLIDAY, JOHN	Harbour Trust, Melbourne, Victoria.
	1869 Apr. 6.	HAMBLETON, FRANCIS HENRY	Hambleton & Co., Baltimore, U.S.
	1897 Apr. 6.	HAMBY, GEORGE HENRY ..	Town Hall, Lowestoft.
	1895 Dec. 3.	*HAMER, WILLIAM HENRY ..	89 Clifton Road, Rugby.
	1882 Feb. 7.	*HAMILTON, EDWARD	Rigwood, Saltburn-by-the-Sea.
t ✠	1900 Jan. 9.	HAMILTON, PATRICK, B.Sc. (*Glas.*)	66 Victoria Street, S.W.
	1892 Mar. 1.	HAMILTON, RICHARD GORDON	Standard Bank of South Africa, Durban, Natal.
	1891 Feb. 3.	*HAMMOND, PHILIP	United Railways, Havana, Cuba.
	1902 Feb. 4.	*HAMMOND, ROBERT WHITEHEAD	64 Victoria Street, S.W.
	1882 May 23.	*HAMP, HENRY JOSEPH	Surveyor, Swindon.
	1901 Dec. 3.	*HANBURY, HERBERT WOOD ..	8 Dunearn Street, Glasgow.
	1900 Mar. 6.	*HANCKEL, ALFRED WOODS, M.Sc. (*Victoria*)	King, King & Co., Bombay.
	1891 Dec. 1.	*HANCKEL, ROBERT STUART ..	Casilla 377, San José, Costa Rica.
	1883 Dec. 5.	HANCOCK, HARRY	Box 192, Klerksdorp, Transvaal.
	1895 Dec. 3.	HANCOCK, HENRY LIPSON ..	Moonta Mines, South Australia.
	1894 Apr. 3.	*HANDCOCK, HENRY WILLIAM	5 Albion Road, Sutton, Surrey.
	1876 Feb. 1.	HANDLEY, HENRY JOHN .. .	
	1899 Jan. 10.	*HANNA, ROBERT FARRAN, B.A.I. (*Dubl.*)	Madras Ry. Co., Madras.
	1893 Feb. 7.	HANNING, THOMAS	2 Collingwood St., Newcastle-on-Tyne.
	1895 Dec. 3.	HANSARD, VICTOR HANSARD ..	Grosvenor Club, Piccadilly, W.
	1881 Jan. 11.	HANSON, JOHN HENRY .. .	20 Ramsden Street, Huddersfield.
	1900 Dec. 4.	HANSSEN, CARL THOMAS ALFRED	319 Lordship Lane, East Dulwich, S.E.
	1904 Jan. 12.	*HARDCASTLE, HENRY ARTHUR	Waterworks, Newcastle-on-Tyne.
	1893 Dec. 5.	HARDIE, WILLIAM	Gasworks, North Shields.
	1904 Jan. 12.	HARDING, WALLACE ALAN DOUGLAS	S. Pearson & Son, Admiralty Harbour, Dover.
m	1874 Mar. 3.	*HARDINGHAM, GEORGE GATTON MELHUISH	Clun House, Surrey Street, Strand, W.C. (Hardingham, London.)
	1894 Mar. 6.	*HARDMAN, ERNEST WILLIAM	24 Talbot Road, Highgate, N.
	1890 Dec. 2.	*HARDWICK, FRANCIS WILLIAM, M.A. (*Oxon.*)	University College, Sheffield.
	1890 Dec. 2.	*HARDY, CHARLES CHETWODE ..	77 Church Road, Horfield, Bristol.
	1902 Mar 4.	*HARFELD, OSCAR	Sergiewskaja 63, St. Petersburg.
	1884 Mar. 4.	HARGREAVES, CHARLES FLEMING	Caixa 531, Rio de Janeiro.
	1880 Dec. 7.	HARGROVE, JOHN EDWARD ..	1 Colville Mansions, Kensington Park, W.
	1903 Apr. 7.	HARKER, BERNARD BROTHERTON	11 Queen's Road Central, Hong Kong.
	1895 Feb. 5.	HARKER, WILLIAM	Cannon Street House, E.C.
	1898 Dec. 6.	HARLEY, ALFRED FRANCIS ..	Mandarin, Florida, U.S.
	1888 Jan. 10.	HARLEY, ARTHUR	Rosslyn, Westbourne Road, Forest Hill, S.E.
	1904 Apr. 12.	HARLEY-MASON, JOHN HARLEY	34 Dulwich Road, Herne Hill, S.E.
	1897 Mar. 2.	HARLOCK, HAROLD	Lamorna, Cleveland Road, Ealing, W.
	1890 Jan. 14.	*HARNETT, ARTHUR	Thames Conservancy, Embankment [E.C.
	1891 Feb. 3.	HARPER, HERBERT WILLIAM ..	13 St. Helen's Place, E.C.
	1904 Jan. 12.	HARPER, JAMES	N.E. Ry., Monte Caseros, Argentina
	1893 Dec. 5.	HARPER, LOUIS	115 Union Street, Aberdeen.

	Date of Election.	ASSOCIATE MEMBERS.	
✠	1886 Dec. 7.	Harper, Walter Andrew ..	13 St. Helen's Place, E.C.
	1897 Apr. 6.	Harrap, George Thomas ..	5 Budge Row, Cannon St., E.C.
	1896 Dec. 1.	Harris, Gordon William ..	Merryweather & Sons, Greenwic Road, S.E.
	1895 Dec. 3.	Harris, John Parker	21 Delahay Street, Westminster, S.V
	1883 Feb. 6.	Harris, Richard	3 Vinery Villas, Regent's Park, N.V
	1889 Dec. 3.	Harris, Samuel Charles ..	54 Cannon Street, E.C.
	1889 Dec. 3.	*Harrison, Arthur	Town Hall, Walworth Road, S.I
	1879 Mar. 4.	*Harrison, Edmund Pontifex	Box 116, Jeppestown, Johannesbur Transvaal.
	1889 Dec. 3.	Harrison, Edward Henry ..	7 Carteret St., Westminster, S.W.
	1904 Apr. 12.	Harrison, Francis Ernest Henry, B.A. (*Cantab.*) ..	12a Wentworth Place, Newcastl on-Tyne.
	1884 Feb. 5.	Harrison, George Howard ..	Thornton, near Ryde, I.W.
	1900 Jan. 9.	*Harrison, Herbert Edward Hyde	Liverpool Waterworks, Llanford Oswestry.
	1885 Apr. 14.	Harrison, Hugh Erat, B.Sc. (*Lond.*)	28 Sussex Place, Regent's Park, N.V
† ✠	1887 Dec. 6.	Harrison, Joseph	Royal College of Science, Kensin ton, S.W.
	1892 Apr. 5.	*Harrison, Octavian John Alfred	15 Hencroft Street, Slough.
	1888 May 1.	*Harrison, Oliver Herbert ..	Tapachula, Chiapas, Mexico.
	1887 May 24.	Harrison, William Joseph ..	7 Carteret Street, Westminster, S.V (Rubrica, London.)
	1901 Dec. 3.	Harrison, William Stuart ..	China and Japan Telephone Co Hong Kong.
	1879 May 27.	Harrisson, Thomas Harnett	Central Buildings, North Joh Street, Liverpool.
	1891 Feb. 3.	Harston, William..	Town Surveyor, High St., Dartfor
	1869 Feb. 2.	Hart, Charles	3 Avenue Road, Leamington.
	1877 Feb. 6.	Hart, James	Summerfield, Christopher P.O King Co., Washington, U.S.
	1899 Apr. 11.	*Hart, John Russell, B.A. (*Cantab.*)	c.o. A. W. S. Cross, 53a Maddo Street, W.
	1894 Dec. 4.	*Hart, Patrick Campbell ..	134 St. Vincent Street, Glasgo (Guarantee, Glasgow. Argyle 0185
	1892 Dec. 6.	*Hart, Thomas	Tharsis Mines, Huelva, Spain.
	1893 Jan. 10.	Hartley, John	11 Monks Hall Grove, Eccles.
	1886 Mar. 2.	*Hartley, Richard James ..	Waterworks Engineer, Gibbet Hil Halifax.
	1867 Apr. 2.	Hartree, William..	Havering, Tunbridge Wells.
	1904 Jan. 12.	Harty, George Spencer, B.A., B.A.I. (*Dubl.*)	Ranelagh, Merrion Road, Ball bridge, Dublin.
	1892 Jan. 12.	Harvey, Francis George ..	Le Désir, Canal No. 1, Demerara.
	1896 Feb. 4.	Harvey, Francis Joseph ..	Cook & Sons, 13 Esplanade Roa Bombay.
	1904 Apr. 12.	*Harvey, Frank Stewart ..	H.M. Dockyard, Devonport.
	1899 Dec. 5.	*Harvey, Herbrand	11 East 32nd Street, New York, U.S
	1890 May 6.	Harvey, John Brown	Reid Company, St. John's, Nev foundland.
† ✠	1880 Dec. 7.	Harvey, *Sir* Robert	1 Palace Gate, W.
	1892 Dec. 6.	Harvey, Robert Falkland	17 Water Street, Liverpool.
S † ✠	1873 Apr. 1.	Harvey, Thomas Fletcher ..	Merthyr Tydfil.
	1892 Feb. 2.	*Harvey, Thomas Francis ..	Purland Chase, Ross, Herefordshir
	1904 Apr. 12.	Harvie, Thomas White ..	"Rossville," Holmhead Road, Cath cart, Glasgow.
✠	1885 Feb. 3.	Hasegawa, Kinske..	Imperial Taiwan Rys., Taipeh Formosa, Japan.
	1898 Feb. 1.	Haselden, Arthur	Linares, Jaen, Spain.
	1900 Feb. 6.	*Hassard, Arthur, B.A.I. (*Dubl.*)	Congested Districts Board, 23 Rut land Square, Dublin.

Date of Election.	ASSOCIATE MEMBERS.	
1890 May 6.	HASSARD, CHARLES	Relief Works, Mushroom Valley, Wynburg, Orange River Colony.
1896 Dec. 1.	*HASSELL, WILLIAM FRANCIS ..	Wwlwye, All Saints Road, Clifton, Bristol.
1900 Dec. 4.	HASTINGS, HAROLD	39 Clock House Road, Beckenham.
1897 Mar. 2.	*HATT, JOHN JOSEPH	410 London Road South, Lowestoft.
1883 May 1.	HAUGHTON, WALTER RALEIGH	Eastern Bengal State Ry., Sealdah, Calcutta.
1902 Jan. 14.	HAULTAIN, HERBERT EDWARD TERRICK	Box 702, Nelson, British Columbia.
1891 May 5.	HAWES, FREDERICK BENJAMIN OLIPHANT	1 Wellington Chambers, Buckingham Gate, S.W.
1904 Apr. 19.	HAWES, ROBERT DONALDSON	L. & S. W. Ry., Engineers' Office, Waterloo, S.E.
1894 Dec. 4.	HAWKINS, ISAAC THOMAS ..	P. W. D., Lagos, West Africa.
1897 Apr. 6.	*HAWKINS, PERCY	Vellore, North Arcot, Madras.
1893 May 2.	HAWKINS, RUPERT SKELTON ..	Assam-Bengal Ry., Chittagong, Bengal.
1892 Feb. 2.	*HAWKINS, SYDNEY SANDERSON	Assam Ry., Dibrugarh, Assam.
1893 Dec. 5.	*HAWKINS, T. HAROLD	3 Rua da Bandeirinha, Oporto.
1900 Apr. 3.	*HAWKINS, TOM SHIRLEY ..	Admiralty, Avenue House, Northumberland Avenue, W.C.
1895 May 21.	HAWKSLEY, JOSEPH	Waterworks, Great Yarmouth.
1893 Dec. 5.	HAWLEY, CECIL EDWARD .	c.o. F. Bell, 15 Queen Street, E.C.
1891 May 5.	HAWTREY, ALBERT NICHOLLS	12 Ella Road, Crouch Hill, N.
1897 Apr. 6.	HAY, JOHN ANGUS	Dick, Kerr & Co., 110 Cannon St., E.C.
1890 May 6.	HAYCROFT, JAMES ISAAC, M.E. (*Queen's*)	Ocean St., Woollahra, Sydney, N.S.W.
1904 Jan. 12.	HAYES, GEORGE PATRICK, B.A., B.E. (*Royal*)	Royal Dockyard, Devonport.
1879 Dec. 2.	HAYES, HERBERT EDWARD HORACE	Kurunegala, N.W.P., Ceylon.
1876 Dec. 5	HAYES, JOHN	11 Church Street, Carnarvon.
1897 Jan. 12.	HAYES, ROBERT THOMAS ..	District Council, Acton, W.
1902 Dec. 2.	HAYWARD, THOMAS WILLIAM ALFRED	Boro' Surveyor, Stamford.
1900 Dec. 4.	*HEAD, BENJAMIN WRIGHTSON, B.A. (*Cantab.*)	47 Victoria Street, S.W. (Westminster 237.)
1894 Feb. 6.	*HEAD, D'ESTERRE PRITTIE ..	Govt. Rys., Maritzburg, Natal.
1898 Apr. 5.	*HEAD, HENRY COLEMAN ..	Gasworks, Branksome, Bournemouth.
1895 Dec. 3.	HEAP, HERBERT	16 Manor Avenue, Grimsby.
1882 Dec. 5.	HEAPHY, FRANCIS BRADSTREET	Ermington Villa, Fawnbrake Avenue, Herne Hill, S.E.
1883 Feb. 6.	HEAPHY, THOMAS MUSGRAVE	19 Lombard Street, E.C.
1873 May 20.	*HEATH, ARTHUR HENRY	34 Parliament Hill Mansions, Highgate Road, N.W.
1898 Dec. 6.	HEATH, ASHTON MARLER ..	Crown Agents' Office, Whitehall Gardens, S.W.
1893 Feb. 7.	HEATH, REGINALD HEPBURN ..	B.B. & C.I. Ry., Bombay.
1893 May 16.	*HEATHCOTE, CHARLES FRANCIS	Tasmania Gold Mine, Beaconsfield, Tasmania.
1898 Dec. 5.	*HEATHCOTT, JOHN M.Sc. (*Victoria*)	Engineer's Office, London County Council, Spring Gardens, S.W.
t ✠ 1892 Jan. 12.	HEATHER, HENRY JAMES SHEDLOCK, B.A. (*Oxon.*)	Barberton, Transvaal.
1891 Apr. 7.	HEATLIE, ARTHUR, B.A. (*Cantab.*)	Govt. Rys., Queenstown, Cape Colony.
1890 May 6.	HEATLY, HARRY	Ballygunge, West Hill Road, S.W.
1895 Apr. 2.	*HEATON, FREDERICK GEORGE ..	King Street, Wigan.
1884 Jan. 8.	HEATON, GEORGE	King Street, Wigan.
1898 Jan. 10.	*HEATON-ELLIS, SYDNEY THOMAS EDWARD	65 Duke's Avenue, Muswell Hill, N.

Date of Election		Associate Members.	
	1889 Dec. 3.	*Hebb, Sidney Bedford Bevis	Klein Engineering Co., 94 Mark Street, Manchester.
✠	1892 Dec. 6.	Hebbert, Ernest George, B.A. (*Cantab.*)	Aysgarth, Tunbridge Wells.
m	1886 Dec. 7.	*Hebblethwaite, Frank Hirst	
	1896 Dec. 1.	*Heberden, Louis Edward ..	Paarl-French-Hoek Ry., Paar Cape Colony.
	1900 Apr. 3.	Heckford, Harley	Council Offices, High St, Poplar, I
	1896 Dec. 1.	Hector, William	Rodney Irrigation & Water Suppl Trust, Tatura, Victoria.
	1886 Mar. 2.	*Hederstedt, William Robert Paul	London County Council, Sprin Gardens, S.W.
	1904 Jan. 12.	Hedgeland, Edmund Woodhouse, B.E. (*Sydney*)	Royal Survey Dept., Bangkok, Siar
	1876 Dec. 5.	Hedgman, William Southwood	75 Upper Ground Street, S.E.
	1900 Dec. 4.	*Hefford, Charles Nelson, M.Sc. (*Victoria*)	22 Chapel Lane, Headingley, Leed
✠	1889 Feb. 5.	Heinké, Edwin Harry Alfred	6 Downleaze, Stoke Bishop, Bristo
	1896 May 19.	*Hemingway, William	9 Ranelagh Avenue, Hurlinghar S.W.
	1904 Jan. 12.	Henderson, Aidan Nicholas	Works Department, H.M. Dockyar Portsmouth.
	1904 Apr. 12.	Henderson, Archibald ..	Harbour Engineer's Office, Aberdee
	1893 Dec. 5.	Henderson, Arthur James ..	Thames Ditton, Surrey.
	1890 Feb. 4.	*Henderson, Hector William Baillie	Brisbane, Queensland.
	1904 Jan. 12.	Henderson, John Gordon, B.Sc. (*Glas.*)	The Institution of Civil Engineer Great George Street, S.W.
	1892 Mar. 1.	Henderson, John James ..	N.W. Ry., Sukkur, Sind, India.
	1900 Dec. 4.	Henderson, John Macdonald	King Street Engineering Work Aberdeen. (Cranes, Aberdeen.)
	1885 Jan. 13.	*Henderson, Stephen, M.A. (*Aberd.*)	63 Pitt St., Sydney, N.S.W.
	1904 Apr. 12.	Heney, George Parr	H.M Naval Station, Garden Islan Sydney, N.S.W.
	1902 Dec. 2.	*Hennell, Thomas Blackburn	18 Airlie Place, Dundee.
	1893 Mar. 7.	Henninger, Daniel	11 General Camara, Rio de Janeir
	1881 Dec. 6.	*Henriques, Cecil Quixano . *Lt.-Col. 1st Middlesex R.E.* (*Vols.*)	15 Victoria Street, S.W.
	1896 Jan. 14.	*Henriques, Edgar Henry Quixano	18 Cambridge Road, Southport.
	1903 Apr. 7.	Henry, Walter	Municipal Offices, Cheltenham.
	1892 Dec. 6.	Henson, Joshua Binnington	Hunter District Board, Newcastl N.S.W.
	1902 Jan. 14.	*Henty, Maurice Walter ..	Topham, Jones & Railton, Ne Bute Dock, Cardiff.
	1902 Dec. 2.	Hepburn, Charles Graham	169 King Street, Sydney, N.S.W.
	1883 Dec. 4.	*Herbert, Arthur William ..	Roadside Bag, Maritzburg, Natal.
	1893 Mar. 7.	Herbert, David William ..	Poona, Bombay Presidency.
	1897 Dec. 7.	Herdman, George Walker, M.A., B.Sc. (*Edin.*)	Govt. Hydraulic Engineer's Office Pretoria, Transvaal.
	1891 Mar. 3.	Hernu, Arthur Henry ..	69 Victoria Street, S.W.
	1891 Dec. 1.	Herriot, William Scott ..	19 Kier Street, Pollokshields Glasgow.
	1895 Mar. 5.	Hesketh, John	Postal Telegraph Dept., Brisbane Queensland.
	1896 Feb. 4.	*Heslop, John George	Highways Surveyor's Office, Castle Eden, co. Durham.
	1878 Feb. 5.	*Hess, Albert Josiah	8 Finch Lane, E.C.

	Date of Election.	ASSOCIATE MEMBERS.	
t ✠	1896 Mar. 3.	Hetherington, Joseph	Cumbria, Hayes, Middlesex.
	1901 Apr. 2.	*Hetherington, Roger Gaskell, M.A. (*Cantab.*) ..	3 Broadlands Road, Highgate, N.
	1874 Dec. 1.	Hewat, William Marshall	Ministry of Public Works, Cairo.
	1898 Apr. 5.	Hewett, Bertram Henry ..	Grant House, The Fort, Bombay.
	1900 Dec. 4.	*Hewett, Bertram Henry Majendie	
	1895 Apr. 2.	Hewitt, Alfred Herbert ..	Green Island Cement Co., Hong Kong. [Bristol.
	1876 Feb. 1.	Hewitt, George Colthurst	Serridge House, Coalpit Heath,
	1889 May 21	*Hewson, George	Boro' Engineer's Office, Leeds.
	1894 Dec. 4.	*Hewson, Thomas, Jun. .. .	Park Cottage, Roundhay, Leeds.
	1904 Jan. 12.	Hewson, Walter, B.Sc. (*Lond.*)	41 Elm Grove Road, Barnes, S.W.
	1903 Mar. 3.	*Heywood, Thomas Edward Hett	Insein, Burma.
	1904 Apr. 12.	Hibberd, Charles Frederick Maxwell	Carnaby Chambers, Carnaby Street, W.
t ✠	1900 Feb. 6.	Hibbins, William George ..	339 Crookes Moor Road, Sheffield.
	1890 Dec. 2.	Hick, George William	24 Chepstow Place, W.
	1904 Jan. 12.	*Hickman, Deverell	20 Alleyn Park, West Dulwich, S.E.
	1896 Dec. 1.	*Hickson, George Forster ..	P.W.D., Perth, Western Australia.
	1889 Dec. 3.	Higgens, Thomas Waghorn Elford	25 Finborough Road, Fulham Road, S.W.
	1896 Dec. 1.	Higgins, Francis Bovill ..	Bacares Iron Ore Mines, Séron, Almeria, Spain.
	1890 Feb. 4.	*Highet, David John	Kwala Lumpur, Selangor, S.S
	1884 Dec. 2.	*Highet, Robert Swan	East Indian Ry., Calcutta. [wich.
	1883 May 1.	*Hight, Arthur Edward ..	Whitlingham House, Thorpe, Nor-
	1902 Apr. 8.	*Hildage, Henry Thomas ..	
	1891 Mar. 3.	*Hildred, Edward Thomas ..	1 High Street, Gosport.
	1889 May 7.	Hill, Alexander	Merrylee, Northwood, Middlesex.
	1894 Dec. 4.	*Hill, Alfred	George Law, Kidderminster. [E.
C m ✠	1888 May 15.	*Hill, Alfred John	North Dene, Higham Rd., Woodford,
	1884 Jan. 8.	*Hill, Arthur, C.I.E., F.C.H.	King, King & Co., Bombay.
	1899 Apr. 11.	*Hill, Charles Harold ..	Madras Ry., Siruvallur, Madras.
	1893 May 2.	Hill, Claude William ..	Broad Street House, E.C. (Hillocking, London. Central 3503)
	1901 Jan. 8.	*Hill, David Gay	N.E.Ry., Engineers' Office, Newcastle-on-Tyne.
	1873 Apr. 1.	Hill, James Woodward ..	City Engineer's Office, Bloemfontein, Orange River Colony.
	1892 Dec. 6.	*Hill, Joseph Ball	Town Hall, Calcutta.
	1874 Apr. 14.	Hill, Leslie Craswellen ..	Hastings Exploration Syndicate, Nelson, British Columbia.
	1886 May 18.	Hill, William	Waterworks, Belfast. [Birmingham.
	1887 May 3.	Hill, William	40 Wellington Road, Edgbaston,
	1880 May 25.	Hill, Woodman	5 Victoria Street, S.W. [E.
	1885 Feb. 3.	Hills, Arnold Frank	Thames Ironworks, Canning Town,
	1895 Dec. 3.	*Hills, Harry James .. .	Town Hall, Bermondsey, S.E.
t ✠	1901 Feb. 5.	*Hincks, Harold Thornthwaite	Mysore Gold Mining Co., Marikuppam, Mysore State, India.
	1893 Feb. 7.	*Hinde, William Henn . ..	2 Lower Merrion Street, Dublin.
	1897 Jan. 12.	*Hindle, Arthur	44 Abingdon Street, Blackpool. (159.)
	1900 Dec. 4.	*Hindley, Clement Daniel Maggs, M.A. (*Cantab.*) ..	c.o. H. S. King & Co., Pall Mall, S.W.
	1903 Jan. 13.	*Hindley, Oliver Walter, B.A. (*Cantab.*)	King, King & Co., Bombay.
	1902 Apr. 8.	Hindmarsh, Ralph Frederick	Tyne Pier Works, South Shields.
✠	1895 Dec. 3.	Hinton, Reginald James ..	St. John del Rey Mining Co., Morro Velho, Brazil.

	Date of Election.	ASSOCIATE MEMBERS.	
	1896 Dec. 1.	HIRST, RICHARD PILLING ..	Boro' Engineer's Office, Southpo[rt]
	1889 Jan. 8.	HISCOCKS, ALFRED MOSER ..	65 Southchurch Road, Southend-[on-]Sea.
	1891 Dec. 1.	*HOBBS, CHARLES JAMES	Hydraulic Eng. Co., 9 Bridge Str[eet]
	1888 Dec. 4.	*HOBBS, GEORGE	Famagusta Harbour, Cyprus. [S
t ✠	1900 Feb. 6.	*HOBLER, GEORGE ALEXANDER	Cairn's Railway, Cairns, Queensla[nd]
	1894 Feb. 6.	*HOBLEY, CHARLES WILLIAM ..	Coton Road, Nuneaton.
	1870 Dec. 6.	HOBSON, JOHN FALSHAW . .	Washington Ironworks, Durham.
	1900 Dec. 4.	HOBSON, WALTER DALBY ..	Nantlle, Penygroes, N. Wales.
	1878 Jan. 15.	HODGE, JOHN LAKEMAN ..	21 Sea View Terrace, Lips[on,] Plymouth.
	1892 Apr. 5.	HODGE, LEONARD PERCIVAL ..	P.W.D., Georgetown, British Guia[na]
	1890 Apr. 1.	*HODGKIN, PHILIP ELIOT ..	Cornerways, Maitland Road, Re
	1889 Dec. 3.	HODGKINSON, GEORGE .. .	Surveyor, St. Anne's, Lancs. [i
	1888 Dec. 4.	HODGKINSON-CARRINGTON, ALFRED JAMES	312 Dashwood House, New Br[oad] Street, E.C.
	1901 Apr. 2.	HODGSON, EDWARD	Town Hall, Sunderland.
	1886 Dec. 7.	*HODGSON, JOHN SLACK	24 Bride Lane, Fleet Street, E.C
	1897 Apr. 6.	*HODSON, FREDERIC WALTER ..	G. & F. W. Hodson, Loughboro[ugh]
	1894 Mar. 6.	*HOFFMANN, JOHN ISIDORE ..	Rand Club, Johannesburg, Transv[aal]
	1904 Jan. 12.	*HOGARTH, WILLIAM HUGH ..	G.I.P. Ry., Bombay.
	1886 Feb. 2.	*HOGG, ALEXANDER JABEZ ..	Southern Mahratta Ry., Bangal[ore,] India.
	1892 Jan. 12.	*HOLDEN, ALFRED	Surveyor, Hindley, Wigan.
	1898 Apr. 5.	HOLDEN, FRANCIS JOHN GERALD, B.A. (*Cantab.*) ..	Electric Supply Co., Seamer Ro[ad,] Scarborough.
	1890 May 20.	HOLDEN, GEORGE HENRY ..	Hardman & Holden, Miles Platti[ng,] Manchester.
	1891 Dec. 1.	HOLDEN, JAMES	Ash Cottage, Ely, Cardiff.
	1893 Dec. 5.	HOLFORD, WILLIAM GEORGE ..	Box 2927, Johannesburg, Transva[al]
m ✠	1888 Mar. 6.	*HOLLIDAY, JOHN	St. James's Gate Brewery, Dubli[n]
	1904 Feb. 2.	*HOLLIDAY, JOHN	4 St. Thomas Road, Harlesden, N
	1897 Apr. 6.	*HOLLINGSWORTH, ARNOLD HACKNEY	P.W.D., Hong Kong.
	1897 Feb. 2.	HOLLINGSWORTH, HORACE CHARLES	G.W.Ry., 150 Westbourne Terr[ace,] W.
	1900 Dec. 4	*HOLLINGWORTH, EDWARD WILLIAM, M.A. (*Cantab.*) ..	16 Ulundi Road, Blackheath, S.1
	1892 May 3.	HOLME, CLINTON JAMES WILSON	1 Crosshall Street, Liverpool.
	1888 Dec. 4.	HOLMES, EDWARD	327 Fulwood Road, Sheffield.
	1892 Mar. 1.	*HOLMES, GEORGE WILLIAM ..	Town Hall, Walthamstow, E.
	1899 Jan. 10.	*HOLMES, JOHN LLEWELLYN ..	Port Trust, Rangoon, Burma.
	1873 Dec. 2.	HOLMES À COURT, *Hon.* ARTHUR WYNDHAM	c.o. Truslove & Hanson, 143 Ox[ford] Street, W.
	1897 Apr. 6.	*HOLMES À COURT, *Hon.* HENRY WORSLEY	H. Lovatt, Contractor's Of[fice,] Broadway, Salford.
	1875 Jan. 12.	HOLT, GEORGE HENRY	20 Richmond Terrace, Blackbur[n]
	1883 Feb. 6.	*HOLT, PERCY WILLIAM MONCKTON	14 Burleigh Street, Auckland, N
	1883 May 29.	HOLTTUM, WILLIAM HENRY ..	County Council, Spring Gardens, S
	1890 May 20.	HOLTZAPFFEL, GEORGE WILLIAM	13 New Bond Street, W.
	1896 Dec. 1.	*HOMAN, WILLIAM MACLEAN ..	Bethlehem, Orange River Colon[y]
	1891 Dec. 1.	*HOMERSHAM, EDWIN COLLETT	19 Broad Street Avenue, [E.C.] (London Wall 554.)
	1884 Jan. 8.	HONEYSETT, ARTHUR	39 Victoria Street, S.W.
	1900 Dec. 4.	*HOOD, DAVID WILSON	Trinity House, Tower Hill, E.C.
	1884 Dec. 2.	HOOLEY, COSMO CHARLES ..	Crofts Bank House, Davyhu[lme,] Manchester.
	1886 Dec. 7.	HOOLEY, EDGAR PURNELL ..	County Surveyor, Nottingham.
	1891 Dec. 1.	HOOPER, EDWARD	Salisbury House, London Wall, E

Date of Election.	ASSOCIATE MEMBERS.	
1901 Apr. 2.	*HOOPER, GEORGE ERNEST ..	Snowdon Rd., Bournemouth West.
1899 Feb. 7.	*HOOPER, PERCY NICHOLAS ..	69 Poppleton Road, Leytonstone, N.E.
1899 Apr. 11.	*HOPE, ALARIC	Heath Heys, Woodchurch Rd., Birkenhead.
1877 Dec. 4.	HOPKINSON, ALFRED	15 Agur Street, Bury.
1889 May 7.	*HOPKINSON, FREDERICK THOMAS	61 Hope Street, Liverpool.
1896 May 19.	HOPKINSON, WILLIAM HENRY	23 Devonshire St., Keighley.
1891 Dec. 1.	HOPWOOD, JOHN	G. W. Ry., Mendoza, Argentina.
1902 Dec. 2.	*HORE, PERCY PHILIP	219 Mitcham Lane, Streatham, S.W.
1882 Apr. 4.	HORN, DAVID BAYNE, F.C.H.	King, Hamilton & Co., Calcutta.
1886 Apr. 6.	*HORN, TOM ALEXANDER	11 Gray St., Waterloo Rd., S.E.
1874 Dec. 1.	*HORN, WILLIAM EDWARD ..	5 Tierney Road, Streatham Hill, S.W.
1889 Dec. 3.	HORNER, WALTER	2 Vancouver Road, Catford, S.E.
1900 Jan. 9.	HORSBURGH, ELLICE MARTIN, M.A., B.Sc. (*Edin.*)	11 Granville Terrace, Edinburgh.
1904 Jan. 12.	HORSBURGH, HARRY	76 Manor Road, Brockley, S.E.
1902 Dec. 2.	HORTON, JOHN WILLIAM ..	County Surveyor's Office, Hatfield.
1903 Feb. 3.	*HORWOOD, CUTHBERT BARING	Box 1030, Johannesburg, Transvaal.
1894 Dec 4.	*HORWOOD, JOEL HENRY, M.C.E. (*Melb.*)	Municipal Engineer, Lahore, Punjab.
1899 Dec. 5.	HOSGOOD, WALTER JAMES ..	Station House, Port Talbot.
1895 Mar. 5.	*HOSKEN, ARTHUR FAYRER ..	Nizam's Rys., Secunderabad, Deccan.
1897 Apr. 6.	HOSKEN, RICHARD	Box 667, Johannesburg, Transvaal.
1883 May 1.	HOSKINGS, ARTHUR BERRIMAN	7 Northbrook Road, Lee, S.E.
1894 Jan. 9.	HOUGHTON, SIDNEY ALEXANDER	Board of Trade Consultative Dept., 54 Victoria Street, S.W.
1904 Jan. 12.	*HOUNSFIELD, FRANCIS CECIL ..	168 Erlanger Road, S.E.
1904 Jan. 12.	*HOUNSFIELD, LESLIE HAYWOOD	Oxhey Hall, Watford, Herts.
1891 May 22.	*HOVIL, FRANK	Cuban Central Railways, Sagua la Grandé, Cuba.
1897 Jan. 12.	HOWARD, ALBERT HARRIS ..	2 Queen Anne's Gate, Westminster, S.W. (Westminster 191.)
1901 Jan. 8.	*HOWARD, FRANCIS ELIOT ..	99 Queen Victoria Street, E.C.
m ✠ 1886 Dec. 7.	*HOWARD, FRANK GEERE ..	7 Ellerdale Road, Hampstead, N.W.
1894 Dec. 4.	HOWARD, FREDERICK WILLIAM	Boro' Engineer's Office, Reading.
1886 May 18.	HOWARD, JOHN GEORGE	Box 550, Johannesburg, Transvaal.
1883 Dec. 4.	HOWARD-SMITH, WILLIAM ..	20 Victoria Street, S.W.
1891 Feb. 3.	*HOWARTH, FRANK	Water Engineer, Plymouth.
1889 Mar. 5.	HOWATSON, ANDREW	88 Avenue de Neuilly, Neuilly, Paris
1902 Apr. 8.	HOWDLE, BENJAMIN	98 Littledale Rd., Seacombe, Cheshire.
1896 Dec. 1.	HOWELL, HEBER WILLIAM HENRY	King, Hamilton & Co., Calcutta.
1883 May 29.	HOWELL, SAMUEL EARNSHAW ..	The Brook Steel Works, Sheffield. (Howell. Sheffield.)
✠ 1897 Feb. 2.	*HOWLEY, RICHARD JOSEPH ..	British Electric Traction Co., 1 Adelphi Terrace, W.C.
1891 Dec. 1.	*HOWLEY, WILLIAM JOHN ..	P.W.D., Bezwada, Kistna, Madras.
1897 Apr. 6.	HOWSIN, CECIL GASCOYNE ..	B. B. & C. I. Ry., Loco. Supt.'s Office, Bombay.
1898 Dec. 6.	HUBBACK, THEODORE RATHBONE	Seremban, Negri Sembilan, Singapore, S.S.
1892 Mar. 1.	*HUDDART, JOHN	Victoria Road, Buckhurst Hill, Essex.
1882 Dec. 5.	*HUDLESTON, ANDREW JOHN ..	S. M. Ry., Dharwar, Bombay.
1897 Apr. 6.	HUDSON, ALFRED	Raise View, Grasmere, Westmorland.
1879 May 27.	HUDSON, JAMES CADOUX ..	75 Upp. Ground St., Blackfriars, S.E.
1899 Apr. 11.	*HUDSON, WALTER	George Findlay & Co., Cape Town, C.C.
1892 Dec. 6.	*HUGHES, EDWARD MORGAN ..	8 Fairholme Road, Great Crosby, Liverpool.

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	1904 Apr. 12.	Hughes, Francis Edward Harold	87 Adelaide Road, Brockley, S.
	1900 Dec. 4.	Hughes, Frederic Selby, B.Sc. (*Victoria*)	Bengal-Nagpur Ry., Calcutta.
	1891 Feb. 3.	Hughes, Herbert William ..	24 Wolverhampton Street, Dudl
	1890 Feb. 4.	*Hughes, William George Crawford	8 Gorst Road, Wandsworth C mon, S.W.
	1878 May 28.	*Hughes, Willoughby Rochester	Harbour Works, Chin-Wang- China.
	1904 Jan. 12.	*Hull, Gerald Edwin ..	Resident Engineer's Office, Ben India. [Rug
	1896 May 5.	*Hull, Henry Adin	L. & N. W. Ry., Anson Ho
	1894 Dec. 4.	*Hull, Percy Winstanley ..	Pauling & Co., 26 Victoria Street, S
	1896 Feb. 4.	*Hulme, Edwin	20 North John Street, Liverpool
	1892 Dec. 6.	Human, Edwin	Technical College, Colo Ceylon.
	1900 Apr. 3.	Hume, Albert Stewart ..	L. & Y. Ry., Lower Newla Brighouse, Yorks.
	1879 Apr. 1.	Hume, Edward Nathaniel ..	Warwick Lodge, Stonebridge P Harlesden, N.W.
	1876 Dec. 5.	Hume, Washington	11 Ironmonger Lane, E.C. (Bank 2
	1898 Dec. 6.	*Hummel, Frank Harvey ..	Mason College, Birmingham.
	1894 Dec. 4.	*Hummel, Horace James Jordan	Homefield, Berlin Rd., Catford,
	1902 Apr. 8.	*Humphrey, Barnard	
	1894 May 1.	*Humphreys, Henry Howard	28 Victoria Street, S.W.
	1885 Feb. 3.	Humphrys, Norton Henry ..	Gasworks, Salisbury.
	1893 Feb. 7.	*Hunt, Bernard	Hunt & Sacré, 1 Victoria Street, S
	1892 Feb 2.	*Hunt, Edward	Algeceiras Railway, Gibraltar.
	1886 Mar. 2.	*Hunt, Henry Charles Terrett	1 Victoria Street, S.W.
	1900 Apr. 3.	*Hunt, Louis John	Sandycroft Foundry, Hawar Chester.
	1895 Dec. 3.	*Hunter, Adam	32 Victoria Street, S.W.
	1883 Dec. 4.	Hunter, Ashley John	Shortland Street, Auckland, N.Z
	1904 Jan. 12.	Hunter, Campbell Murray, B.A. (*Cantab.*)	1 Leadenhall Street, E.C.
	1899 Dec. 5.	Hunter, George Lewis ..	Guildhall, Newcastle-on-Tyne.
m ✠	1888 Feb. 7.	*Hunter, Gilbert Macintyre	4 Marian Terrace, Selkirk, N.B.
	1879 Feb. 4.	*Hunter, John	Quarry Bank, Belper.
	1889 Feb. 5.	*Hunter, Maurice	Bridge Street, Belper.
	1897 Apr. 6.	Hunter, Walter James ..	Grand Junction Waterworks, K Bridge, W. [castle-on-Ty
✠	1895 Dec. 3.	Hunter, William Gallon ..	55 Northumberland Street, Ne
✠	1901 Apr. 23.	*Hurley, Frederick Arthur, F.C.H.	Public Works Ministry, Cairo.
	1897 Dec. 7.	Hurse, Alfred Edward ..	1 Cobham Terrace, Greenhithe.
	1903 Apr. 7.	Hurst, Bertram Lawrance ..	Assistant Civil Engineer, H Dockyard, Portsmouth.
	1902 Dec. 2.	*Hurst, George Frederick ..	16 Park Road, Coalville, Leiceste
	1898 Dec. 6.	Husband, James	Victoria Lodge, High Road, Ch wick, W.
W t ✠	1897 Mar. 2.	Husband, Joseph	98 Mona Rd., Spring Vale, Sheffie
	1900 Apr. 3.	Huston, William Edward ..	Fairman Place, Academy Ro Londonderry.
	1889 Apr. 2.	Hutchings, Charles Arthur	40 Mattock Lane, Ealing, W.
	1898 Apr. 5.	*Hutchinson, Henry Western	Wingfield, Stoke, Devonport.
	1895 Dec. 3.	*Hutchinson, William Haines	Dunwood, Endon, Stoke-on-Trent
	1894 Jan. 9.	*Hutchison, George Lean, B.Sc. (*Glas.*)	5 University Avenue, Glasgow.
	1902 Apr. 8.	*Hutchison, William	Canadian Pacific Ry., Fort Willia Ont., Canada.
	1886 Dec. 7.	*Hutton, Charles Herbert ..	King, King & Co., Bombay.

	Date of Election.	ASSOCIATE MEMBERS.	
	1879 May 6.	HUTTON, THEODORE BENT ..	4 Sketty Road, Swansea
	1887 Apr. 5.	*HUTTON, WALTER HERBERT ..	3, St. Andrew's Road, West Kensington, W.
	1895 Dec. 3.	*HUTTON, WILLIAM	Burnpark, Uddingston, Glasgow.
	1902 Dec. 2.	HYDE, GEORGE	Parkholme, Prescot Road, St. Helens, Lancs.
	1895 Dec. 3.	HYSLOP, JOHN	27 Walton Well Road, Oxford.
	1876 Mar. 7.	I'ANSON, WILLIAM	Bardencroft, Saltburn-by-the-Sea.
	1888 Dec. 4.	*IKIN, ARTHUR JOHN	405 11th Street, Sacramento, California, U.S.
	1895 May 21.	*INGHAM, WILLIAM	Town Hall, Port Elizabeth, C.C.
m	1901 Feb. 5.	*INGLIS, CHARLES EDWARD, B.A. (*Cantab.*)	Maitland House, Cambridge.
	1901 Apr. 2.	*INGLIS, JOHN, B.Sc. (*Edin.*) ..	122 George Street, Edinburgh.
✠	1881 Feb. 1.	*INGLIS, WILLIAM	Rosedale, Airdrie, N.B.
	1900 Dec. 4.	INGOLDBY, THOMAS EDWARD, B.A. (*Cantab.*)	Glengariff, Coleraine Road, Westcombe Park, S.E.
	1901 Apr. 2.	INMAN, CECIL DAUBENY	Harbour Works, Table Bay, Cape Colony.
	1892 May 3.	IRONSIDE, WILLIAM DALTON ..	3 Golden Square, Aberdeen.
✠	1899 Jan. 10.	IRVINE, FEARNSIDE	3 Nutley Terrace, Hampstead, N.W.
	1902 Apr. 8.	IRVINE, JOHN	Cheshire Lines, Central Station, Liverpool.
	1896 May 5.	IRVING, DANIEL	Gas Co., Stapleton, Bristol.
	1901 Apr. 23.	IRWIN, ARTHUR JOHN, B.A.I. (*Dubl.*)	Rathmoyle, Castlerea, Ireland.
	1880 Mar. 2.	*ITTER, ARTHUR WERNER ..	Waverley House, Waverley Grove, Hendon, N.W.
	1887 Apr. 5.	*IVE, ERNEST	The Hermitage, Mead Vale, Redhill.
	1880 Dec. 7.	IVENS, THOMAS EDWARD ..	c/o F. H. Ashhurst, 23 Montpellier Road, Ealing, W.
	1892 Dec. 6.	*IVES, HARRY WILLIAM MACLEAN	Sirhind Canal, Ludhiana, Punjab.
	1895 Feb. 5.	IVOR-MOORE, THOMAS	R.E. Office, York.
	1875 Dec. 7.	IZARD, WALTER GEORGE ..	10 The Paragon, Blackheath, S.E.
	1887 Dec. 6.	*JACK, ARTHUR JOSEPH	The Crouch, Seaford, Sussex.
	1885 May 19.	*JACKAMAN, CHARLES JAMES ..	Highfield, Bath Road, Slough.
	1888 Apr. 10.	JACKS, THOMAS WILLIAM MOSELEY	7 Clarence Drive, Kelvinside, Glasgow.
	1900 Apr. 3.	*JACKSON, ALFRED ERNEST	City Engineer's Office, Manchester.
t ✠	1899 Dec. 5.	*JACKSON, CLEMENTS FREDERICK VIVIAN, B.E. (*Sydney*) ..	Geological Survey Office, Perth, Western Australia.
	1883 May 29.	JACKSON, EDWARD JAMES ..	Kinburn West, St. Andrews, N.B.
✠	1891 Dec. 1.	*JACKSON, GEORGE FREDERICK	N. E. Ry., Newcastle-on-Tyne.
	1900 Dec. 4.	*JACKSON, HARRY	36 Chalsey Road, Brockley, S.E.
	1887 Apr. 5.	*JACKSON, HUGH ROWLAND ..	The Hall Cross, Doncaster.
	1892 Apr. 5.	JACKSON, JAMES EDWARD ..	Killaginle, Roscahill, co. Galway.
	1899 Apr. 11.	JACKSON, JAMES THOMAS, M.A., M.A.I. (*Dubl.*)	13 Kimmage Road, Harold's Cross, Dublin.
	1895 Jan. 8.	JACKSON, ROBERT CATTLEY ..	King's Court, Colmore Row, Birmingham.
	1890 Dec. 2.	JACOB, ALBERT FRANCIS ..	Waterworks, Prospect, N.S.W.
	1879 Feb. 4.	*JACOB, EDWARD FOUNTAINE, C.I.E.	N. W. Ry., Lahore, Punjab.
	1872 Dec. 3.	JACOB, EDWARD WESTLEY ..	39 Great George Street, Harrogate.
	1891 May 5.	JACOBS, PAUL GEORGE	c/o H. S. King & Co., Pall Mall, S.W.
	1887 Jan. 11.	*JACOMB, WILLIAM WYKEHAM ..	72 Dyke Road, Brighton.
	1902 Dec. 2.	*JACOMB - HOOD, MALCOLM SUTHERLAND	9 Bridge Street, Westminster, S.W.

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	1897 Feb. 2.	*JACQUES, HAROLD SISSON ..	29 Montpellier Terrace, Chelten
	1892 Jan. 12.	*JACQUES, HERBERT INNES ..	14 Randall Road, Clifton, Brist
	1890 Jan. 14.	JACQUES, JAMES ROUTLEDGE ..	Woodbank, Whitehaven.
	1878 Jan. 15.	JACQUES, RICHARD	Loco. Supt., Caldera, Chile.
	1902 Jan. 14.	*JAFFE, DANIEL	P.W.D., Hong Kong.
	1893 Dec. 5.	*JAMES, ARTHUR CHARLES ..	District Council, Grays, Essex.
	1889 Jan. 8.	*JAMES, REGINALD WILLIAM ..	St. Mildreds, Cambridge R Bromley, Kent.
	1900 Apr. 3.	*JAMES, WILLIAM HENRY, B.Sc. (*Wales*)	College of Engineering, Che Palace, Madras.
f m ✠	1901 Jan. 8.	*JAMESON, ALEXANDER HOPE, M.Sc. (*Victoria*)	Derwent Valley Water Bo Bamford, Sheffield.
	1880 Feb. 3.	*JAMESON, GEORGE	Bow Street Distillery, Dublin
	1892 Feb. 2.	*JAMESON, HENRY BENTLEY ..	P.W.D., Maritzburg, Natal.
	1895 Dec. 3.	*JAMIESON, FREDERICK ALEXANDER	Imperial Rys., Tongshan, China.
	1901 Dec. 3.	*JAMIESON, WILLIAM	46 Devonshire Road, Liverpool.
	1904 Feb. 2.	*JANSEN, EDWARD CLINTON ..	Municipal Council, Shanghai, Chi
	1895 May 21.	*JANSON, EDMUND WILLIAM, M.A. (*Cantab.*)	23 St. Swithin's Lane, E.C.
	1895 Dec. 3.	JAPP, HENRY	Surrey Commercial Docks, Roth hithe, S.E.
	1881 Jan. 11.	JARVIS, GEORGE EDWARD ..	Tembuland, Umtata, C.C.
	1888 Dec. 4.	*JASPER, NICHOLAS PAUL	13 Charles Street, St. James's, S
	1887 Dec. 6.	JEEJEEBHOY, PIROSHAW BOMANJEE	17 Church Street, Bombay.
	1898 Apr. 5.	*JEFFARES, JOHN LETT SEALEY, B.Sc. (*Edin.*)	Government Railways, Komg Cape Colony.
	1889 Feb. 5.	JEFFERISS, THOMAS	Cornwall Works, Soho, Birmingh
	1881 Dec. 6.	*JEFFREYS, EDWARD HOMER ..	Hawkhills, Chapel Allerton, Le
	1893 Jan. 10.	JEKEN, JOHN LLEWELLYN ..	H.M. Dockyard Extension, Gibral
	1894 Mar. 6.	JEME, TIEN YOW, Ph.B. (*Yale*)	Imperial Railways, Tientsin, Chi
M W t ✠	1891 Feb. 3.	*JENKIN, CHARLES FREWEN, B.A. (*Cantab.*)	Nearcross, Stafford.
	1895 Mar. 5.	JENKIN, CHARLES JAMES ..	Urban District Council, Finchley
	1895 Apr. 2.	*JENKIN, WILLIAM ALFRED ..	Dean Terrace, Liskeard.
	1894 May 22.	*JENKINS, ALFRED JOHN	New Waterworks Co., 27 Br Street, Jersey.
	1895 May 21.	*JENKINS, CHARLES WILLIAM ..	Bonnie Doon, Tamworth, N.S.W
	1890 Feb. 4.	*JENKINS, DAVID MORGAN ..	Borough Surveyor, Neath.
	1878 Feb. 5.	JENKINS, GEORGE GORDON ..	16 Bridge Street, Aberdeen.
	1891 Apr. 7.	JENKINS, HENRY CHARLES ..	5 Deerbrook Road, Herne Hill, S
	1888 Dec. 4.	JENKINS, WILLIAM JOHN ..	Beehive Works, Retford, Notts
	1902 Apr. 8.	JERRAM, GEORGE	19 Merton Road, Walthamstow,
	1876 Mar. 7.	JERVIS, ALEXANDER	23 Claremont Crescent, Edinbur
	1877 Dec. 4.	*JESSOP, GEORGE	London Steam Crane & Engine Wo Leicester. (Jessop, Leicester. 7
	1897 Apr. 6.	JEVONS, JOHN HENRY	Boro' Surveyor, Hertford.
	1900 Apr. 3.	JEX-BLAKE, THOMAS BOWEN, M.A. (*Oxon.*)	Engineer's Office, E.I. Ry., Calcut
	1889 Dec. 3.	JICKELL, SAMUEL	Boro' Engineer, Petone, New Zeala
	1885 Feb. 3.	*JOBLING, EDWARD FISHER ..	2 Spencer Road, Wandsw Common, S.W.
m ✠	1877 Feb. 6.	*JOEL, HENRY FRANCIS	74 Windsor Road, Forest Gate,
	1896 Dec. 1.	*JOHNS, PERCY	Guildhall, Maidenhead.
✠	1885 Mar. 3.	*JOHNS, WILLIAM ARTHUR ..	Altan, Carrickfergus, Ireland.
	1894 Dec. 4.	JOHNSON, ALGERNON EDWARD	Egerton Street, Wrexham.
	1892 Mar. 1.	*JOHNSON, CHARLES THOMPSON	Boro' Engineer, Thornaby-on-Te
	1879 May 6.	*JOHNSON, FREDERICK WILLIAM	Maybank, Staplehurst, Kent.
	1891 Jan. 13.	JOHNSON, HENRY CLEWLY ..	Midland Ry., Engineer's Offi Ambergate.
	1901 Mar. 5.	JOHNSON, JAMES HEALEY ..	Witham Office, Boston, Lincs.
	1898 Apr. 5.	*JOHNSON, PHILIP HEBER ..	Engineers' Office, Midland Ry., Der

Date of Election.	ASSOCIATE MEMBERS.	
1903 Jan. 13.	*JOHNSTON, CHARLES	P.W.D., Begari Canals, Jacobabad, Sind.
1898 Dec. 6.	*JOHNSTONE, ARTHUR HENRY, B.A.I. (*Dubl.*)	Mogulserai Gya Ry., Dehri Bridge, Bengal.
1883 Feb. 6.	JOHNSTONE, *Hon.* CECIL	Hackness Hall, Scarborough.
1900 Dec. 4.	JOHNSTONE, RONALD HENRY ..	190 West George Street, Glasgow.
1876 May 2.	JONES, ALFRED STOWELL, V.C. *Lt.-Col. ret.*	Ridge Cottage, Finchampstead, Berks.
1886 Mar. 2.	JONES, CHARLES EDWIN	9 Manor Terrace, Lea Bridge Road, Leyton.
1877 Mar. 6.	JONES, CHARLES WILLIAM ..	Gasworks, Via dei Cerchi, Rome.
1888 Apr. 10.	*JONES, CYRIL EDWARD ARENGO	Cilymaenllwyd, Llanelly.
1884 May 6.	JONES, EDWARD DUKINFIELD ..	11 Bertram Road, Sefton Park, Liverpool.
1894 Jan. 9.	JONES, ELIAS CHRISTOPHER, B.Sc. (*Lond.*)	5 Rugby Road, Neath.
1891 Dec. 1.	*JONES, EVAN DAVIES	6 Addison Road, Kensington, W.
1903 Jan. 13.	*JONES, EVELYN LLEWELLYN HUSTLER	25 Bernard St., Russell Square, W.C.
1901 Dec. 3.	JONES, FRANK WILLIAM ..	Fernleigh, Green Hill, Derby.
1902 Feb. 4.	*JONES, FREDERICK JAMES ..	Railways, Wellington, N.Z.
1881 Feb. 1.	*JONES, GEORGE ARTHUR	c. o. A. L. Foster, 20 Copthall Avenue, E.C.
1886 Mar. 2.	JONES, HAROLD	45 Gwendwr Road, W.
1904 Apr. 12.	JONES, HENRY LANGLEY ..	64 Aberdare Gardens, South Hampstead, N.W.
1887 May 3.	JONES, JOHN CHARLES DWAFYDD	Eastern Extension Telegraph Co., Singapore, S.S.
1887 Dec. 6.	*JONES, JOHN EDWARD	Eastcliffe, Exton, Topsham.
1875 Feb. 2.	*JONES, JOHN HUNTER	15 First Avenue, Brighton.
1891 Dec. 1.	JONES, MONTAGUE RHYS ..	70 Bishopsgate Street, E.C.
1876 Dec. 5.	*JONES, OWEN	Blackale Range Road, Beeswah, Queensland.
1890 Mar. 4.	*JONES, PATRICK NICHOLAS HILL	P.W.D., Hong Kong.
1901 Dec. 3.	*JONES, SAMUEL CAREY	6 Cwmdonkin Terrace, Swansea.
1896 Apr. 14.	*JONES, THOMAS GILBERT, B.Sc. (*Victoria*)	Municipal Technical College, Swansea.
1876 Feb. 1.	*JONES, WALTER ROBERTS ..	80 Wanstead Park Avenue, Manor Park, E.
1891 Apr. 7.	*JONES, WILLIAM	Trefgarnedd, Meirion Gardens, Colwyn Bay, N. Wales.
1884 Dec. 2.	JONGH, JOHN ISIDOR DE	San José, Costa Rica.
1852 Dec. 7.	JOPLING, JOSEPH	592 Church Street, Toronto, Canada.
1891 Dec. 1.	JOPP, WILLIAM	East India United Service Club, 16 St. James's Square, S.W.
1899 Dec. 5.	*JOSELIN, EDWARD LIVINGSTONE	178 Charles Road, Small Heath, Birmingham.
1884 May 6.	JOSEPH, ALLAN FERGUSON ..	Cairo.
1879 Feb. 4.	*JOSEPHSON, JOSHUA PERCY ..	George St., Marrickville, Sydney, N.S.W.
1891 May 5.	*JOY, HENRY GOLDING	c.o. H. Master, 18 Theobalds Road, W.C.
1896 Mar. 3.	*JUDD, CHARLES RICHARD ..	King, King & Co., Bombay.
1880 Feb. 3.	JULIAN, ROBERT HILL, B.E. (*Queen's*)	Prospect Villa, Braunton, N. Devon.
1904 Apr. 12.	JUPP, JOHN FRANCIS	Parliament Mansions, Victoria Street, S.W.
1884 May 6.	KAPTEYN, ALBERTUS PHILIPPUS	Westinghouse Brake Co., York Rd., N. (Westinghouse, London. King's Cross 620.)
1894 Dec. 4.	KATRAK, NAVROJI HORMASJI	229 Borah Bazar St., Fort P

	Date of Election.	Associate Members.	
	1900 Dec. 4.	KATZENSTEIN, ERNEST	Obras de Saneamiento del Pu Cerrolargo 96F, Montevi Uruguay.
✠	1898 Mar. 1.	KAY, STANLEY ROBERT	1 Albion Place, Leeds.
	1898 Dec. 6.	KAY, WALTER ROBERT	G. and W. R. Kay, Athol St Douglas, Isle of Man.
	1903 Jan. 13.	*KEAY, WILLIAM GREGORY ..	21 Delahay St., Westminster, S.
	1893 Mar. 7.	*KEELING, HUGH TROWBRIDGE	c.o. H. S. King & Co., 65 Cornhill,
m ✠	1899 Dec. 5.	*KEIGWIN, ARCHER DAVE ..	Hodbarrow Mines, Millom, Cum land.
	1887 Mar. 1.	KEIR, FRANCIS LINDSAY.. ..	Ry. Dept., Brisbane, Queenslan
	1904 Jan. 12.	KEITH, DAVID ALEXANDER ..	21 Northumberland Avenue, W.
	1888 Dec. 4.	KEITH, JAMES	27 Farringdon Avenue, E.C. (Ja Keith, London. Holborn 62
	1898 Mar. 1.	KEKEWICH, GEORGE ORMOND	Whitelands, St. George's Road, Margaret's, S.W.
	1893 Jan. 10.	*KELLETT, HARRY	53 Victoria Street, S.W.
	1901 Apr. 23.	*KELLY, ARTHUR CLIFTON ..	British Westinghouse Electric Norfolk Street, Strand, W.C.
	1904 Apr. 19.	KELLY, JAMES	Rossall Road, Thornton, Poul le-Fylde.
	1882 Mar. 7.	KEMBLE, FREDERICK	24 Church St., Kingston, Jamai
	1894 Feb. 6.	KEMP, JOHN	City Engineer, Brisbane, Que
	1889 Feb. 5.	KEMP, WILLIAM EDMUND ..	D.P.W., Sydney, N.S.W. [h
	1881 May 31.	KEMPSON, CHARLES..	Corporation Buildings, Leiceste
	1890 Dec. 2.	*KEMPSON, CHARLES ALDWIN..	Dockyard, Liverpool.
	1896 Jan. 14.	*KEMP-WELCH, JOHN	Holmwood, The Crescent, Barne
	1890 Dec. 2.	KENDALL, ROBERT	Existing Lines Dept., Sydney, N.S
	1878 Feb. 5.	*KENDALL, WILLIAM BARROW ..	184 Park Avenue, Hull.
	1899 Dec. 5.	*KENNEDY, ROBERT SINCLAIR ..	41 Marquess Road, Canonbury,
	1895 Dec. 3.	KENNEDY, THOMAS	Ry. Construction Dept., Syd N.S.W.
✠	1892 Dec. 6.	KENNY, WILLIAM EYRE.. ..	P.W.D., Kuala Lumpur, Ma States.
	1888 Feb. 7.	KENT, JOHN BROADHURST ..	Commercial Gas Co., Poplar, E.
	1898 Dec. 6.	*KENT, ROBERT JACKSON ..	King, King & Co., Bombay.
	1876 Mar. 7.	KENWORTHY, EDWIN	18 Holly Road, Handsworth, St
	1900 Dec. 4.	*KENYON, FRANCIS EDWARD ..	Gillingham Hall, Beccles.
	1902 Jan. 14.	KER, ANDREW MARTIN, B.Sc. (*Victoria*)	Boro' Surveyor's Office, Warring
	1896 Feb. 4.	KER, ARTHUR WILLIAM ..	Patella Works, Paisley, N.B.
	1899 Dec. 5.	KER, JOHN STUART, B.Sc. (*Edin.*)	7 Lismore Street, Warwick R Carlisle.
	1899 Dec. 5.	KERMODE, GEORGE, M.C.E. (*Melb.*)	City Engineer, Hawthorn, Vict
	1893 Dec. 5.	KERR, JOSEPH MALCOLM	Gokak Falls, Belgaum Dist India.
	1887 May 3.	*KERSHAW, FREDERICK WHITE	3 Conyers Avenue, Birkdale, So port.
	1903 Feb. 3.	KHAREGAT MARCUS MERWAN RUTTONJEE	P. W. D., Ootacamund, Madras
	1876 Feb. 1.	KIDD, THOMAS	104 Balham Park Road, S.W.
	1893 Feb. 7.	KIDD, THOMAS	Swadlincote, Burton-on-Trent.
	1900 Apr. 3.	*KIESER, WILLIAM HENRY GUSTAV	City Engineer's Office, Bristol.
	1889 Feb. 5.	KIKKAWA, SANJIRO	4 Bambamachi, Honjoku, T Japan.
	1897 Dec. 7.	KILGOUR, MARTIN HAMILTON..	Municipal Offices, Cheltenham
	1893 Jan. 10.	*KILLON, HARRY BIRCH	Heaton Moor, near Stockport.
	1892 Jan. 12.	*KINDERSLEY, ARTHUR EDWARD	Anuradhapura, Ceylon.
	1894 Dec. 4.	*KING, CHRISTOPHER WATKINS	Harbours & Rivers Branch, D.P. Newcastle, N.S.W.

Date of Election.	ASSOCIATE MEMBERS.	
1892 Dec. 6.	KING, FRANCIS ALEXANDER STUART	Arklow, Ireland.
1900 Jan. 9.	KING, ROBERT HENRY, B.A.I. (*Dubl.*)	Punchard, Lowther & Co., H.M. Dockyard Extension, Hong Kong.
1904 Apr. 19.	KING, ROBERT	P.W.D., Newcastle, Natal.
1882 May 23.	*KINGDON, ZACHARY HARRIS ..	H.M. Dockyard, Sheerness.
1888 Jan. 10.	KINGSFORD, HERBERT	Casilla 120, Lima, Peru.
1890 May 20.	KINGSLEY, ARTHUR HENRY, B.A. (*Cantab.*)	Fanshaws, Hertford.
1896 Dec. 1.	KINGSTON, HENRIQUE AUGUSTO	Govt. Telegraphs, Rio de Janeiro.
1892 Dec. 6.	KIRBY, JAMES NOBLE	Eng.'s Office, Midland Ry., Derby.
1896 May 19.	KIRBY, JOHN FREDERICK CAMPBELL	Thos. Cook & Son, Bombay.
✠ 1894 Jan. 9.	KIRBY, OSCAR JOHN	Town Hall, Batley.
1877 May 29.	KIRK, THOMAS	Town Hall, Ipswich, Queensland.
1888 Feb. 7.	KIRKALDY, JOHN	101 Leadenhall Street, E.C.
: ✠ 1898 Dec. 6.	KIRKALDY, WILLIAM GEORGE	Testing Works, 99 Southwark St., S.E. (Hop Exchange 203.)
1901 Apr. 23.	KIRKLAND, JOHN, M.Sc. (*Victoria*)	Hawthorn Bank, Rocky Lane Monton, Manchester.
1898 Dec. 6.	*KIRKPATRICK, CYRIL REGINALD SUTTON	26 Sanderson Road, Newcastle-on-Tyne.
1895 Mar. 5.	KIRKPATRICK, THOMAS HENRY	Roads & Bridges Dept., Sydney, N.S.W.
1897 Jan. 12.	*KIRKWOOD, JAMES HOWIE, B.Sc. (*Glas.*)	Orme Bank, St. Andrew Street, Ayr, N.B.
1897 Apr. 6.	*KIRKWOOD, JOHN	Admiralty Harbour Works, Dover.
1884 Apr. 1.	KIRSTEIN, HENRY CHARLES ..	Eliot Vale Cottage, Blackheath, S.E.
1904 Feb. 2.	*KITCHIN, ERIC WILFRED ..	The Priory, Watford, Herts.
m 1901 Apr. 2.	*KITCHIN, JOHN WILLIAM ..	Dock Engineer's Office, Cumberland Basin, Bristol.
1872 Jan. 9.	KITT, ALFRED	Downsland, Crondall, Hants.
1873 Jan. 14.	KITT, BENJAMIN	Sydney Lodge, Bathwick, Bath.
1894 Mar. 6.	*KLOPP, GEORGE ONNO HOMFELD	200 High Holborn, W.C. (c.o. Kentobin, London).
1904 Apr. 12.	KNAPMAN, EDWARD	3 Queen's Crescent, Haverstock Hill, N.W.
1891 Dec. 1.	KNIGHT, BERTRAND THORNTON	Ry. Dept., Pak D'joing, Siam.
1897 Jan. 12.	KNIGHT, CLAUD HOPE	Jaltipan, Vera Cruz, Mexico.
1904 Jan. 12.	*KNIGHT, JOHN ARTHUR, B.Sc. (*Victoria*)	Great Central Railway Contract, Wembley.
1900 Feb. 6.	KNIGHT, JOHN MACKENZIE ..	Bushwood, Wanstead, Essex.
1896 Jan. 14.	KNIGHTS, RICHARD	Little Massingham, King's Lynn.
1888 May 1.	*KNOWLES, ARTHUR JAMES, B.A. (*Cantab.*)	27 Campden House Chambers, Campden Hill, W.
1890 Dec. 2.	KNOWLES, CHARLES EDWARD ..	Holmdale, Glossop, Manchester.
1895 Jan. 8.	KNOWLES, GEORGE WILLIAM ..	Raincliffe, Clevedon, Somerset.
1888 Feb. 7.	KNOWLES, ROBERT	Ednaston Lodge, near Derby.
1894 Dec. 4.	KOCH, AUGUST CHARLES	District Office, Ry. Dept., Wellington, N.Z.
1904 Jan. 12.	KÖHRING, ALFRED WILLIAM ..	Engineer's Office, G. S. & W. Ry., Inchicore, Dublin.
1893 Dec. 5.	KOLLE, HAROLD WERNER ..	Egremont, Tulse Hill, S.W.
1901 Feb. 5.	KONDO, SENTARO	Doboku Kantokusho, Tokio, Japan.
1882 Apr. 4.	*KORTRIGHT, LAWRENCE MOORE	Basseterre, St. Kitts, West Indies.
1898 Dec. 6.	KRAUS, JACOB	Polytechnic School, Delft, Holland.
1901 Apr. 2.	*KÜHL, HARRIS JÜRGEN CARL ..	21 Delahay Street, Westminster, S.W.

1893 Dec. 5.	LABASTIDE, ALBERT FRANCIS DE	Port of Spain, Trinidad.
1887 Feb. 1.	*LABATT, JOHN BAGOT	Brougham Place, N. Adelaide, S Australia.

	Date of Election.	Associate Members.	
	1896 Dec. 1.	Lacey, Joseph Melville .	Ex. Eng., P.W.D., Nidadavo Godavery, India.
m	1883 May 29.	*Lacey, Thomas Stephen ..	Gas Light & Coke Co., Bromley-b Bow. E.
	1891 Dec. 1.	Lachlan, William	E. F. Novo Hamburgo, Porto Alegr Rio Grande do Sul, Brazil.
	1894 May 22.	Lackland, John James.. ..	Water Engineer, St. Helens, Lanc
	1894 Dec. 4.	Lackland, William Samuel	Holderness Drainage, Beverle Yorks.
	1896 Apr. 14.	*Lade, Alexander	L.C.C.Works Dept., Belvedere Roa
	1902 Apr. 22.	Laffère, Richard Lawson, M.A.I. (*Dublin*)	47 Marlborough Road, Donnybroo Dublin.
	1903 Mar. 3.	*Lagerwall, Frank Gordon	Aberdeen S. N. Co.'s Wha Limehouse, E.
	1896 Dec. 1.	Lailey. Charles Nicholson	6 The Sanctuary, Westminster, S.
	1901 Dec. 3.	*Laing, John Ross	7 Denham Green Avenue, Leith.
	1895 May 21.	*Laing, William Arthur Baird	13 George Street, Edinburgh.
	1898 Apr. 5.	Lake, Vivian Davey ..	S. Pearson & Son, Seaham Harbou Durham.
	1889 May 7.	*Lake, William George Woolloombe	Box 1970, Johannesburg, Transvaa
	1904 Mar. 1.	*Lamb, Ernest Horace, M.Sc. (*Victoria*)	41 Alexandra Road, Bedford.
	1893 Dec. 5.	Lambert, FitzGerald Gage	B. & N.W. Ry., Bhagalpur, India.
	1882 Mar. 7.	*Lambert, George Buchanan	Madanapalle, Madras.
	1895 Apr. 2.	*Lambert, Joshua	712 High Road, Tottenham, N.
	1889 Dec. 3.	*Lancashire, William Thomas	Deputy City Surveyor, Sheffield.
	1892 May 3.	Lancaster, Edward William	1 St. Ann's Chambers, Orchar Street, Westminster, S.W.
	1889 Dec. 3.	Lancaster, William Joseph Cosens	The Kraal, St. Julian's Farm Roa West Norwood, S.E.
	1888 Feb. 7.	*Lander, Philip Vincent ..	Compania de Obras Publicas, Av nida de Mayo 586, Buenos Aire
	1895 Dec. 3.	Landless, James Thomas ..	Station Buildings, Nelson, Lancs.
	1897 Mar. 2.	Lane, Frederick Paget ..	23 East Cliff, Dover.
	1887 Dec. 6.	Lane, George..	Gasworks, Aylesbury.
	1904 Jan. 12.	*Lane, Hugh Septimus	Madawachchi. N.C.P., Ceylon.
	1895 Feb. 5.	*Lane, Stanley Arthur ..	H.M. Dockyard Extension, Keyham Devonport.
	1904 Apr. 19.	*Lane, Thomas Reginald Pelham	Moundsley Hall, King's Norton Worcestershire.
	1880 Dec. 7.	*Lang, John Charles . ..	Liskeard, Cornwall.
	1882 Mar. 7.	*Lange, Frederick Montague Townshend..	72A St. Thomas Street, S.E.
	1897 Mar. 2.	Langford, William Morris	Galatz Waterworks, Roumania.
	1890 Mar. 4.	*Langston, Alfred Cecil ..	H. S. King & Co., Pall Mall, S.W.
f m ✠	1902 Apr. 8.	*Lapworth, Herbert, B.Sc. (*Birm.*)	Derwent Valley Water Boar Bamford, Sheffield.
	1895 Dec. 3.	Larard, Charles Edward ..	Northampton Institute, Clerken
	1886 Mar. 2.	*Large, Charles John Edmonds	Brecon.
	1898 Dec. 6.	Larmor, William Wright, B.A. (*Royal*)	Banbridge, co. Down.
	1899 Dec. 5.	La Roche, Charles Augustus	Kybor Pass, Auckland, N.Z.
	1900 Dec. 4.	*Lart, Frederick Arthur ..	17 Victoria Road, Darlington.
	1896 May 5.	*Lashmore, Ernest Ward ..	Willway Street Depot, Bristol.
W t ✠	1886 Apr. 6.	Last, William Isaac	Machinery Division, Victoria Albert Museum, S. Kensington, S
	1899 Apr. 11.	Latham, George Baldwin ..	Parliament Mansions, Vict Street, S.W.
	1892 Apr. 5.	*Latimer, Hugh Haughton ..	Apartado 385, Mexico City.
	1901 Apr. 2.	*La Trobe-Bateman, Frederic Winfried	36 Kensington Mansions, Ear Court, S.W.

Date of Election.	ASSOCIATE MEMBERS.	
1883 May 29.	*Laurence, Reginald	Gothic Works, Norwich.
1893 Dec. 5.	*Laurens, Frank	Norfolk Park, Maidenhead.
1901 Dec. 3.	Laurie, Gordon Colet.. ..	Heron Court, Brentwood.
1894 Dec. 4.	*Laurie, Kenneth Smale ..	Heron Court, Brentwood.
1878 May 28.	Lavey, Charles	19 Arundel Square, Barnsbury, N.
1897 Mar. 2.	Law, George Ernest	P. W. D., Perth, Western Australia.
1890 May 20.	Law-Green, Charles	50 Hampton Road, Southport.
1896 May 5.	Lawn, James Gunson	Box 231, Johannesburg, Transvaal.
1899 Dec. 5.	*Lawrence, Richard Priestley	Govt. Rys., Salt River, Cape Town, C.C.
1897 Mar. 2.	*Laws, Bernard Courtney ..	Lloyd's Register, 3 St. Nicholas Buildings, Newcastle-on-Tyne.
1892 May 3.	*Lawson, Albert William ..	Municipal Offices, Rawtenstall.
1882 May 2.	Lawson, Charles Griffin ..	Dist. Council, Palmer's Green, N.
1889 Dec. 3.	*Lawson, Charles Henry ..	90 Boundary Road, N.W.
1886 Feb. 2.	Lawson, Vincent Alexander	Stroud, Gloucestershire.
1888 Dec. 4.	Lawton, Richard Johnson ..	47 Waldegrave Park, Twickenham.
1892 Mar. 1.	*Lazenby, Arthur, B.A. (*Cantab.*)	Ranmore, Rugby.
1901 Apr. 2.	Lea, Frederick Charles ..	22 Stracey Road, Harlesden, N.W.
1902 Dec. 2.	Lea, Frederick Mackenzie..	38 Bennetts Hill, Birmingham.
1904 Feb. 2.	Lea, Richard Smith, Ma.E. (*McGill*)	Montreal, Canada.
1900 Dec. 4.	*Leader, Hugh	Thorndene, Oakleigh Park, N.
1898 Dec. 6.	Leaf, Edward Huntingdon, B.A. (*Cantab.*)	Burlington Lodge, Streatham Common, S.W.
1898 Dec. 6.	Leaf, Henry Meredith, B.A. (*Cantab.*).	Burlington Lodge, Streatham Common, S.W.
1898 Dec. 6.	*Leake, Henry Cooke	4 Collingwood Villas, Stoke, Plymouth.
1903 Apr. 7.	Leask, Henry Norman.. ..	Heenan & Froude, 4 Chapel Walks, Manchester.
1895 Dec. 3.	*Leaver, Cyril D'Arcy ..	Field House, Harpenden, Herts.
1878 May 28.	Lee, Edwin	Ferncliffe, Harehills Avenue, Leeds.
1890 May 20.	Lee, John, M.A. (*Oxon.*) ..	10 Bisham Gardens, Highgate, N.
1866 May 1.	Leechman, William Carey ..	3 Greystone Buildings, South St., Eastbourne.
1895 Dec. 3.	Lees, Herbert	Gasworks, Hexham.
1883 Mar. 6.	*Lees, Oswald Campbell ..	19 Pembroke Road, Kensington, W.
1891 Mar. 3.	Leete, William Henry ..	Shire Hall, Bedford.
1887 Mar. 1.	Lefroy, George Anthony ..	c.o. Union Bank, Perth, Western Australia.
1904 Apr. 12.	Leggett, Stephen	Siemens Bros., Woolwich.
m 1891 Feb. 3.	*Legros, Lucien Alphonse ..	57 Brook Green, Hammersmith, W.
✠ 1888 Feb. 7.	*Leigh, Frederick James ..	30 Kenilworth Road, Ealing, W.
1895 Jan. 8.	Leigh, John Alfred	Engineer's Office, Ship Canal Co., Eastham, Manchester.
1901 Dec. 3.	*Leitch, Archibald, B.Sc. (*Glas.*)	Walker Engineering Laboratory, University, Liverpool.
m ✠ 1896 Dec. 1.	*Leitch, William Orr, Jun...	Imperial Rys., Tientsin, China.
1892 Feb. 2.	*Le Mesurier, Harry Hunt Peveril	King, Hamilton & Co., Calcutta.
m 1887 May 24.	*Lengerke, Rudolph Emil von	1 Victoria Street, S.W.
1882 May 23.	Lester, Edward Rolls.. ..	13 Whitefield Terrace, Plymouth.
1895 Mar. 5.	*L'Estrange, Francis Samuel	64 St George's Avenue, Tufnell Park, N.
1891 May 12.	*Leventhorpe, John Bonfoy	King, King & Co., Bombay.
1900 Dec. 4.	*Lewis, Arthur Wilfrid ..	Frankley Waterworks, Northfield, Birmingham.
1888 Jan. 10.	Lewis, Frank Beckett	City Architect, Guildhall, Nottingham.

Date of Election.		ASSOCIATE MEMBERS.	
	1892 Jan. 12.	Lewis, Herbert Clark	Hean Castle, Saundersfoot, Pem brokeshire.
	1889 Dec. 5.	*Lewis, John Harry	Surveyor's Office, Blackwood, Mon
	1893 Dec. 5.	*Lewis, John Thorpe	South Indian Ry., Madras.
	1900 Apr. 3.	*Lewis, Ralph Morgan .. .	Admiralty Harbour, Dover.
	1893 Jan. 10.	Lewis, William Thomas Watkin	Eastbrook Hall, Dinas Powis, Glam
	1902 Mar. 4.	*Lewis-Dale, Henry Angley	6 Cambridge Terrace, Chatham.
	1888 Dec. 4.	*Libbis, George Hilder	Wood Bank, Lytham.
	1893 Dec. 5.	*Lightbody, Arthur Edward	Royal Windermere Yacht Clu Bowness, Windermere.
	1902 Jan. 14.	*Lightfoot, Cecil	35 Queen Victoria Street, E.C.
	1877 Dec. 4.	Lilley, Thomas Isaac	3 Victoria Street, S.W.
	1888 Feb. 7.	Lilljeqvist, Johan Rudolf	Bengtsfors, Sweden.
	1881 Feb. 1.	*Linacre, John	Hay, Breconshire.
	1892 Dec. 6.	Linde, Albert de	Tientsin, China.
	1889 May 7.	Lindesay, Charles de la Poire Crawford	Royal Societies Club, St. Jame Street, S.W.
	1879 Dec. 2.	Linging, Frederick Edward	4 Kensington Court Gardens, W.
	1892 Apr. 5.	Lingwood, George	Waterworks, Barbados. [W
	1902 Jan. 14.	*Linscott, Arthur Burrow ..	16 Westbourne Square, Bayswate
	1904 Jan. 12.	Linton, Samuel Edgar Albert	21 Holmewood Road, Streatha Hill, S.W.
	1890 May 6.	Lipscomb, Herbert Nicholson	Loco. Dept., Midland Ry., Liverpoo
	1886 Dec. 7.	Lisboa, Alfredo	Box 883, Rio de Janeiro.
	1904 Apr. 12.	Lismer, Alfred Bass	Town Hall, Croydon.
	1897 Mar. 2.	Lister, Francis Liversedge	Waterworks, Bulawayo, S. Africa.
	1898 Apr. 5.	Lister, Frank Somerset ..	53 Victoria Street, S.W.
	1878 May 28.	Litchfield, Henry Charles	P.W.D., Kimberley, Cape Colony.
	1895 Dec. 3.	Little, Albert George ..	Ry. Construction Branch, P.W.D Sydney, N.S.W.
	1885 Apr. 14.	*Little, Christopher	Ry. Construction Branch, P.W.D Sydney, N.S.W.
	1903 Feb. 3.	*Little, Malcolm	3 Roundhay Terrace, Leeds.
	1889 Dec. 3.	*Little, William Dorrington Boyle	P.W.D., Brisbane, Queensland.
	1902 Dec. 2.	Litton, Francis Henry, B.A.I. (*Dubl.*)	Loco. Supt., Pekin Syndicate Rys Tientsin, China.
	1889 Dec. 3.	Livens, Frederick Howard	Ruston, Proctor & Co., Lincoln.
	1899 Dec. 5.	Liversedge, Alfred John ..	Clock House, Arundel Street, Strand W.C.
	1891 Feb. 3.	*Liversidge, John George, R.N.	H.M. Dockyard, Malta.
	1895 Apr. 2.	*Livesey, Alfred Percival ..	Apartado 566, Havana, Cuba.
	1893 Feb. 7.	Livingstone, George	17 Victoria Street, S.W.
	1884 May 6.	Llobet, Andrés	Montevideo, Uruguay.
	1891 Mar. 3.	*Lloyd, Bell George	Box 126, Lourenço Marquez, Delago Bay, S.E. Africa.
	1890 Jan. 14.	*Lloyd, Charles Vereker ..	c.o. H. S. King & Co., 65 Cornhill, E.C
	1902 Apr. 8.	Lloyd, Cyril Edward	13 Victoria Street, S.W.
	1882 May 2.	*Lloyd, George Augustus Hamilton Fitz-Warrine ..	J. Scrivener, United African Land 20 Bucklersbury, E.C.
	1897 Feb. 2.	*Lloyd, Guy Ernest	Davey, Paxman & Co., Colchester.
	1900 Feb. 6.	*Lloyd, Henry Gardiner ..	11 Chesterton Road, Plaistow, E.
m	1901 Apr. 2.	*Lloyd-Davies, David Ernest	Engineer's Dept., Council House Birmingham.
	1892 Mar. 1.	*Loam, Matthew	Moditonham, Hatt, Cornwall.
	1899 Apr. 11.	Lobley, Francis Joseph ..	District Council, Hale, Cheshire.
	1896 Dec. 1.	*Lobnitz, Henry Calder ..	Strule Farm, Billingshurst, Sussex
	1886 May 4.	Loch, Richard	45 New Walk, Leicester.
	1896 Jan. 14.	*Lochhead, Kerr, B.Sc. (*Glas.*)	68 Manor House Road, Newcastle on-Tyne.
	1901 Apr. 2.	*Locket, Athol	Jokai Tea Co., Panitola P.O. Dibrugarh, India.
	1886 Feb. 2.	*Lockhart, Harold Edward	72 Elmbourne Road, Upper Tooting
	1889 Dec. 3.	Lockyer James Edward ..	Coonoor, Nilgiris, Madras. [S W

	Date of Election.	ASSOCIATE MEMBERS.	
	1898 Mar. 1.	Lodder, Ernest	The Bungalow, River Don, Tasmania.
	1865 Feb. 7.	Loeffler, John Charles Lewis	The Abbey, Campden Hill Rd., W.
	1880 Feb. 3.	Logan, John William, M.P.	Market Harborough.
	1898 Mar. 1.	Logier, Eugene Adolphe	24 Westland Row, Dublin.
	1892 May 3.	Lomax, Charles James	37 Cross Street, Manchester.
	1885 May 5.	Lomax, Walter John	11 Fold Street, Bolton.
	1893 May 2.	*Long, Francis Maddison	Electricity Co., Duke St., Norwich.
	1897 Apr. 6.	Long, Richard Charles	21 Fairacres Road, Oxford.
	1894 Dec. 4.	*Longhurst, Frederick Herdman	c.o. MacFadyean & Co., Winchester House, Old Broad Street, E.C.
	1903 Mar. 3.	*Longley, Robert James	13 Clarendon Place, Leeds.
	1882 Dec. 5.	Longridge, Robert Charles	Kilrie, Knutsford.
	1901 Apr. 23.	Lord, James	21 Savile Crescent, Halifax, Yorks.
	1898 Apr. 5.	Lorimer, John Alexander	Gt. Western Ry., Pernambuco, Brazil.
	1891 Jan. 13.	Louch, John Da Vinci	P.W.D., Auckland, N.Z.
	1883 Mar. 6.	Louth, George Edward	Eng.'s Office, G.W. Ry., Reading.
	1896 Feb. 4.	Love, George Rankin	7 Wellington Place, Guildford.
	1884 Mar. 4.	*Lovegrove, Charles Arthur	P.W.D., Colombo, Ceylon.
B	1902 Dec. 2.	*Lowe, James	Gas Engineer's Office, 45 John Street, Glasgow.
	1890 Dec. 2.	Lowry, Frederick	Ravendale, Hornchurch, Essex.
	1892 Dec. 6.	Luard, Edward Sydney	Grindlay & Co., Parliament Street, S.W.
	1870 Dec. 6.	Lucas, Arthur	27 Bruton Street, W.
	1902 Dec. 2.	*Lucas, Frederic Horace Faviell	Windermere, Laburnham Road, Maidenhead.
	1891 Feb. 3.	Lucas, Samuel Ernest	29 York Crescent Rd., Clifton, Bristol.
	1880 Dec. 7.	Luckstedt, Henry	South Wonston Farm, Micheldever, Hants.
	1891 Feb. 3.	*Lucy, William Theodore	107 Woodstock Road, Oxford
	1888 Feb. 7.	Ludbrook, Samuel William	231 Romford Road, E.
	1891 Dec. 1.	Luff, George Andrew Middlemiss	G.P.O., Wellington, N.Z.
✠	1882 Dec. 5.	Lukis, Ernest du Bois	Mineral de la Aurora, *vià* Teziutlan, Puebla, Mexico.
	1890 Mar. 4.	Lumb, Tom Gallon	24 Birley Street, Blackpool.
	1891 Dec. 1.	Lund, Arthur	7 Victoria Terrace, Bromham Road, Bedford.
	1883 May 29.	*Lungley, Arthur Robert	Fulton & Co., Adelaide, S. Australia.
	1891 Jan. 13.	Lunn, Alfred	Middle Level Drainage, March.
	1904 Apr. 12.	Lyle, George Herbert, B.A.I. (*Dubl.*)	Knocktarne, Coleraine, co. Derry.
	1892 Jan. 12.	Lynam, Francis John, B.E. (*Royal*)	Co. Surveyor's Office, Omagh, Tyrone.
	1891 Dec. 1.	*Lynam, George Trotter	Boro' Engineer, Burton-on-Trent.
	1873 May 6.	Lynch, Edward James	45 Corrêa Dutra, Cattete, Rio de Janeiro.
	1882 Jan. 10.	Lynch, Joseph	Nova Friburgo, Brazil.
	1885 Feb. 3.	Lynde, Frederick Charles	
✠	1899 Apr. 11.	*Lynde, Gerald Gascoigne	Buckland, Ashton-on-Mersey, Cheshire.
	1896 Dec. 1.	*Lyon, Ernest	Calle de Blanco 279, Valparaiso, Chile.
	1858 Feb. 2.	Lyon, George	Valparaiso, Chile.

	1892 May 3.	MacAllister, Robert John Dudley	c.o. Mrs. MacAllister, The Towers, Lewes Road, Eastbourne.
	1895 Feb. 5.	*MacAndrew, Harold	Box 4843, Johannesburg, Transvaal.
	1882 Apr. 4.	McArthur, Duncan William	Boro' Engineer, Waihi, Auckland, N.Z.
	1883 Dec. 4.	MacBean, Malcolm Æneas	Office of Public Works, Glasgow.
	1887 Feb. 1.	McBeath, Alexander Gordon	Montague Road, Sale.

	Date of Election.	ASSOCIATE MEMBERS.	
	1890 May 6	MACBETH, JOHN BRUCE KING	44 Tamarind Lane, Bombay.
	1890 May 20.	McCALLUM, THEOPHILUS SEPTIMUS	40 Blackfriars Street, Manchester
	1898 Feb. 1.	MACCARTHY, JOHN LEADER, B.A., B.E. (*Royal*)	Burn & Co., 7 Hastings Stre Calcutta.
	1898 Dec. 6.	McCAY, SAMUEL, B.E. (*Royal*)	Dick, Kerr & Co., City Chambe Wood Street, Wakefield.
	1900 Apr. 3.	*McCLEAN, WILLIAM NEWSAM, M.A. (*Cantab.*)..	42 Durdham Park, Bristol.
	1890 Feb. 4.	McCLEW, WILLIAM CHARLES	Erin View, Portpatrick, N.B.
	1892 Dec. 6.	*McCOWAT, GEORGE HUTCHESON	8 Regent's Park Square, Strathbung Glasgow.
	1901 Feb. 5.	McCROSKY, JAMES WARREN ..	J. G. White & Co., 22A College Hi Cannon Street, E.C.
	1875 Jan. 12.	McCULLOCH, ALEXANDER ..	25 Gayfield Square, Edinburgh.
	1884 Dec. 2.	*MACDONALD, ANGUS RODERICK	c.o. H. S. King & Co., Pall Mall, S.W
	1902 Dec. 2.	MACDONALD, ARTHUR CAMERON	Casilla 942, Valparaiso, Chili.
	1876 May 30.	MACDONALD, AUGUSTUS VANZANDT	Ry. Dept., Auckland, N.Z.
	1881 May 31.	MACDONALD, DONALD	Kimberley Waterworks Co., 20–2 Laurence Pountney Lane, E.C.
	1888 Dec. 4.	MACDONALD, DONALD GRANT	Urban District Council, Rugby.
	1896 Dec. 1.	MACDONALD, DUNCAN KENNEDY	D.P.W., Akyab Division, Burma.
m	1902 Jan. 14.	*McDONALD, EDWARD SLATER	Waterford & Rosslare Ry., Wellin ton Bridge, co. Wexford.
	1892 Mar. 1.	*MACDONALD, MURDOCH .. .	Nile Reservoir, Assouan, Egypt
	1897 Mar. 2.	MACDOUGALL, ALEXANDER, Jun.	Oakhurst, Westcombe Park, S.E.
	1896 Mar. 3.	McDOUGALL, JAMES, B.A. (*Toronto*)	Court House, Adelaide Street Eas Toronto, Canada.
	1899 Jan. 10.	McDOUGALL, PERCY RAYMOND, M.A. (*Cantab.*)	4 Lansdowne Terrace, Wakefield.
	1885 Feb. 3.	McEWEN, THOMAS SMITH ..	Govt. Rys., Cape Town, C.C.
	1904 Mar. 1.	*McFADYEAN, WILLIAM MATTHEWS	Royal Edward Dock, Avonmoutl Bristol.
	1897 Jan. 12.	*MACFARLANE, RIENZI WALTON	Vehar, Heene Road, West Worth ing.
	1884 Dec. 2.	*MACFARLANE, THOMAS JOHN MALCOLM	Box 1198, Johannesburg, Transva
✠	1883 Dec. 4.	MACGEORGE, LESLIE DUNCAN	High Street, Dunedin, N.Z.
	1890 Dec. 2.	McGLASHAN, PATRICK BLACKSTOCK	Gatehouse, Kircudbrightshire.
	1879 Feb. 4.	MACGREGOR, ALFRED ALEXANDER	Glencairn, Gatley Road, Cheadle Cheshire.
	1876 May 27.	*MACGREGOR, ALEXANDER ..	3 Collingham Gardens, Kensington S.W.
	1904 Jan. 12.	*McGREGOR, STUART WILLIAM BUCHANAN	9 Lonsdale Road, Leytonstone, N.E
	1894 Jan. 9.	*McGUIRE, JAMES CLARK ..	26 Cortlandt Street, New York, U.S
	1893 Apr. 11.	*McINTOSH, HORACE ARTHUR ..	F. C. Central, Montevideo.
	1904 Apr. 12.	MACINTOSH, JAMES RAE, B.Sc. (*Glas.*)	The West Manse, Alva, N.B.
	1891 Jan. 13.	*MACINTYRE, JAMES GILBERT STEVENSON	Rhodesia Railways, Bulawayo, South Africa.
	1897 Feb. 2.	McINTYRE, JOHN TURNBULL ..	Grindlay, Groom & Co., Bombay.
m	1880 May 4.	*MACKAY, JOHN CHARLES ..	Llanwye, Hampton Park, Hereford
	1900 Feb. 6.	*MACKAY, ROBERT GORDON ..	Nürnbergerstrasse 16. I., Berlin.
	1900 Dec. 4.	*MACKENZIE, ALEXANDER RODERICK	Govt. Rys., Maritzburg, Natal.
	1900 Apr. 3.	MACKENZIE, ARTHUR CECIL ..	Fairlight, Edge Cliff, Sydney, N.S.W.
	1890 Dec. 2.	*MACKENZIE, JAMES	Govt. Rys., Ceres, Cape Colony.

Date of Election.	ASSOCIATE MEMBERS.	
1884 Dec. 2.	MACKENZIE OF TARBAT, *Sir* JAMES KENNETH DOUGLAS, *Bart.*	8 Bramham Gardens, Kensington, S.W.
1894 Feb. 6.	*MCKENZIE, LESSEL STEPHEN ..	City Engineer's Office, Bristol.
1889 Dec. 3.	MACKENZIE, THOMAS KENNETH	Box 1876, Johannesburg, Transvaal.
1892 Dec. 6.	MACKENZIE-RICHARDS, PETER FELIX	53 Victoria Street, S.W.
1877 Mar. 6.	MACKIE, CHARLES HASTINGS ..	R M. Ry., Ajmere, India.
1900 Dec. 4.	*MACKILLOP, GARDINER HENDERSON, B.Sc. (*Glas.*)	G.W.Ry., High Wycombe.
1885 May 19.	*MACKINLAY, FREDERICK ..	367 Calle Guido, Buenos Aires.
1900 Jan. 9.	MACKISON, JAMES WALLS, B.Sc. (*Edin.*)	8 Constitution Terrace, Dundee.
1899 Dec. 5.	MACKISON, WILLIAM MAXWELL, B.Sc. (*Edin.*)	Waterworks, Antigua, West Indies.
1880 Dec. 7.	*MACLACHLAN, ALEXANDER ..	7 Laverockbank Road, Trinity, Edinburgh.
1884 Dec. 2.	*MCLAREN, RAYNES LAUDER	10 Lammas Park Gardens, Ealing, W.
1894 Dec. 4.	MACLEAN, CHARLES STEWART DOUGLAS	Eng.'s Office, Midland Ry., Derby.
1901 Apr. 2.	MACLEAN, JOHN	19 University Avenue, Glasgow.
1902 Dec. 2.	*MACLEAN, JOHN MACGAVIN ..	50 Royal York Crescent, Clifton, Bristol.
1901 Feb. 5.	MCLEAN, JOHN ROWLAND JONES	F. C. Pacifico, Calle 25 de Mayo 277, Buenos Aires.
1903 Apr. 7.	*MCLEAN, WILLIAM HANNAH ..	160 Hope Street, Glasgow.
1889 May 21.	*MACLELLAN, WILLIAM TURNER	129 Trongate, Glasgow. (MacLellan, Glasgow.)
1879 Feb. 4.	MACLENNAN, JOSEPH	Portugalete, Bilbao, Spain. (MacLennan, Bilbao.)
1876 Dec. 5.	*MACMAHON, HENRY EUGENE	Leadmore, Branksome Wood Road, Bournemouth.
1889 Dec. 3.	MCMAKING, THOMAS	96 St. Andrew's Road, Southsea.
1893 May 16.	MCMILLAN, HENRY	R. M. Railway, Bandikui, India.
1894 Jan. 9.	*MCMILLAN, JAMES PETER ..	Waterworks, Graaf Reinet, Cape Colony.
1884 May 6.	MCMINN, ARTHUR CHARLES ..	Gas L. & C. Co., Kensal Green, W.
1891 Feb. 3.	*MCMURTRIE, GEORGE EDWIN JAMES	Radstock, near Bath.
1897 Dec. 7.	MCNEILL, BEDFORD	25A Old Broad Street, E.C.
1893 May 2.	MCNEILL, WILLIAM	10 Lower Road West, St. Leonards-on-Sea.
1897 Jan. 12.	MCNELLAN, JAMES EDWARD ..	Robert Hemming, Box 2, Johannesburg, Transvaal.
1896 Feb. 4.	MACPHERSON, MALCOLM	Eng.'s Office, St. Enoch Station, Glasgow.
1887 Apr. 5.	MCPHERSON, JOHN AMBROSE ..	Waterworks Office, Bristol.
1894 May 1.	MCQUEEN, WILLIAM TEMPLE, B.Sc. (*Glas.*)	Railway Administration, Gabbari, Minet El Basal, Alexandria.
1902 Feb. 4.	*MCRITCHIE, CHARLES BELL ..	Heritier Buildings, Jeppe Street, Johannesburg, Transvaal.
1892 May 3.	MACRONE, GRIEVE	G.P.O., Montreal, Canada.
1902 Dec. 2.	*MACTAGGART, JOHN NORMAN CAMPBELL, B.E. (*Sydney*) ..	Metropolitan Board of Water Supply, Sydney, N.S.W.
1892 May 24.	*MADDOCK, PERCY WALTER ..	Honoresfeld, Langham Road, Teddington.
1899 Feb. 7.	*MADDOCKS, ARTHUR PERCY, B.Sc. (*B'ham.*)	48 Nottingham Road, Spondon, Derby.
1897 Dec. 10.	*MADELEY, JAMES WELBY, M.A. (*Cantab.*)	Waterworks, Hayfield, Stockport.
1904 Jan. 12.	MAGEE, FREDERICK WALTER	Aldridge, Walsall.

	Date of Election.	ASSOCIATE MEMBERS.	
	1891 Jan. 13.	MAGINNIS, JAMES PORTER ..	11 Carteret Street, Westminster, S. (P.O. Telephone—Victoria 192
	1884 Apr. 1.	MAHONY, FRANCIS RONAN ..	Water Supply Office, Ballar Victoria.
	1902 Jan. 14.	*MAIR, GEORGE PASCOE	Willans & Robinson, Rugby.
	1891 Apr. 1.	*MAIS, CHARLES LESLIE STEWART	10 Harbor St., Kingston, Jamaica
	1896 Dec. 1.	MAKINSON, THOMAS HENRY ..	G.C. Ry., Haddenham, Bucks.
	1899 Jan. 10.	MALCOLM, JOHN, B.Sc. (*Glas.*)	6 Waterloo Place, S.W.
✠	1891 Dec. 1.	*MALCOLMSON, JAMES WADDELL	Box 327, El Paso, Texas, U.S.
	1901 Mar. 5.	*MALIM, JOHN CHARLES . ..	Works Dept., H.M. Dockyar Chatham.
	1899 Dec. 5.	*MALLAGH, JOSEPH, B.A., B.E. (*Royal*)	Markethill, co. Armagh.
	1889 Dec. 3.	MALLALIEU, FRANCIS MAYALL	Box 715, Johannesburg, Transvaal
	1894 Dec. 4.	MALSCH, CHARLES CHRISTIAN ..	Constitutional Club, S.W.
	1904 Apr. 19.	MALTBY, FREDERIC THOMAS ..	South Street, Dorchester.
	1894 Apr. 3.	MANN, GEORGE	10 Polmuir Road, Aberdeen.
	1891 May 5.	MANN, JABEZ	Sevenoaks.
	1886 Jan. 12.	MANN, JOHN RANDALL	Beaumont House, The Woodland Isleworth.
	1895 May 21.	MANNING, WILLIAM ROBERT ..	25 Baskerville Road, Wandswort Common, S.W.
	1898 Dec. 6.	MANSEL, ROBERT	Umbilo P.O., Durban, Natal.
	1897 Jan. 12.	*MANSERGH, WALTER LEAHY .	Elm Bank, Frognal Lane, N.W.
	1904 Jan. 12.	MANSFIELD, JAMES FRANCIS ..	Central London Ry., Shepherd Bush Depôt, W.
	1881 Feb. 1.	*MANWARING, HENRY HARE ..	107 Manor Road, Brockley, S.E.
	1883 May 1.	*MARJORIBANKS, DUDLEY SINCLAIR	
	1893 Jan. 10.	*MARKBY, WALTER	24 Westbourne Terrace Road, W.
	1903 Apr. 7.	*MARKHAM, CECIL CARY	6 Dixon Terrace, Darlington.
	1892 Dec. 6.	*MARKS, EDWARD CHARLES ROBERT	13 Temple Street, Birmingham.
t ✠	1884 Mar. 4.	*MARKS, GEORGE CROYDON ..	18 Southampton Buildings, Chancer Lane, W.C. (Abecedary, Londo Holborn 836.)
	1887 Apr. 5.	*MARKS, HENRY CAPNER	City Surveyor, Carlisle.
	1901 Dec. 3.	MARRIAN, ARTHUR EDWARD ..	Royal Marine Depôt, Deal.
	1887 Feb. 1.	*MARRIAN, FREDERIC YORK ..	5 Prince's Parade, Muswell Hill, N
	1904 Apr. 12.	*MARRIAN, HAROLD GREENWOOD	Town Hall, Manchester.
	1894 Dec. 4.	*MARRINER, WILLIAM WRIGHT	Park View, Croom's Hill, Green wich, S.E.
✠	1898 Apr. 5.	MARSH, CHARLES FLEMING ..	East London Waterworks, Clapto N.E.
	1889 Feb. 5.	*MARSH, DOUGLAS EARLE ..	G. N. Ry., Loco. Dept., Doncaster.
	1887 May 3.	*MARSH, LEONARD SWAINE MORTLOCK	Waterworks Office, Sheffield.
	1886 Dec. 7.	*MARSHALL, HERBERT AUGUSTUS	Châlet des Grands-Vignes, Sathonay Ain, France.
	1889 May 7.	MARSHALL, JENNER GUEST ..	Tyndall Works, Sloane Street, Birmingham.
	1902 Jan. 14.	*MARSHALL, JOHN SCOTT	Dick, Kerr & Co., 18 Guildhall Street, Preston.
	1893 Mar. 7.	MARSHALL, LAUNCELOT PAUL	Northern Outfall Works, Beckton, E
	1888 May 15.	MARSTON, CHARLES FREDERICK	44 High Street, Sutton Coldfield.
	1892 May 24.	*MARSTON, EDWARD HOWIS ..	21 Queen's Road, Beckenham, S.E.
	1884 Feb. 5.	MARSTON, GEORGE DALLAS ..	G.I.P. Ry., Bombay.
	1893 Dec. 5.	MARTEN, HENRY	Avonside House, Keynsham, Bristol.
	1884 May 27.	*MARTEN, HENRY JAMES	Surveyor's Office, 215 Balham High Road, S.W.
	1898 Apr. 5.	MARTIN, ARTHUR JOHN	7 Victoria Street, S.W.
	1896 Dec. 1.	*MARTIN, ERNEST BRANWHITE	City Eng.'s Office, Leeds.
	1893 Apr. 11.	*MARTIN, ERNEST METEOR ..	Hanwell, W.

	Date of Election.	ASSOCIATE MEMBERS.	
	1901 Dec. 3.	MARTIN, ERNEST SYDNEY ..	3 Esplanade, Calcutta.
	1878 Feb. 5.	MARTIN, GEORGE	c.o. R. M. Heald, 103 Streatham Hill, S.W.
	1893 Dec. 5.	MARTIN, GEORGE HENRY ..	3 Bayham Road, Rusthall Avenue, Turnham Green, W.
	1904 Jan. 12.	*MARTIN, GEORGE THOMAS BARNES	Caixa 403, Rio de Janiero, Brazil.
	1887 Dec. 6.	MARTIN, JOSEPH ERNEST	Nizam's Ry., Secunderabad, India.
	1903 Apr. 7.	*MARTIN, ROBERT EDMUND, M.A. (*Cantab.*)	The Brand, Loughborough.
	1877 Mar. 6.	MARTIN, THOMAS HENRY ..	New Barnet, Herts.
	1903 Apr. 21.	*MARTIN, VINCENT JOSEPH, M.Sc. (*Victoria*)	5 Rose Lane, Mossley Hill, Liverpool.
	1886 May 18.	MARTIN, WILLIAM JAMES ..	Aguas Corrientes, Rosario de Santa Fé, Argentina.
	1888 Dec. 4.	*MARTINDALE, WARINE BEN HAY	Haistwell House, Sunningdale, Berks.
	1890 Dec. 2.	*MARTINEAU, HOWARD	Thistlehurst, Westerfield Road, Ipswich.
	1893 Mar. 7.	*MARTIN-LEAKE, RICHARD ..	Marshalls, Ware, Herts.
✠	1888 Dec. 4.	*MARTIN-LEAKE, STEPHEN ..	Marshalls, Ware, Herts.
	1880 Dec. 7.	MARTYN, GEORGE VALENTINE	6 West Cliff Terrace, Ramsgate
	1899 Dec. 5.	MASON, ARTHUR JOSEPH	St. Mary's Hall, Coventry.
	1887 May 3.	MASON, CHARLES	Foster & Pearson, Beeston, Notts.
	1897 Mar. 2.	MASON, CHARLES GEORGE ..	Boro' Surveyor, Guildford.
	1898 Dec. 6.	MASON, WILLIAM, B.Sc. (*Victoria*)	7 Bridge Street, Heywood, Lancs.
	1877 Dec. 4.	*MASON, WILLIAM JOSHUA ..	Woodville, Lovelace Road, Surbiton.
	1881 May 31.	MASSEY, JOHN DUNHAM	8 Princes Street, E.C.
	1888 Apr. 10.	MASSIE, FRANK	Tetley Ho., Kirkgate, Wakefield.
	1901 Apr. 2.	*MASTER, ROBERT CREASY ..	Master & Ashcroft Bros., Ramah, viâ Wingate, New Mexico, U.S.
	1884 Feb. 5.	MASTERMAN, CHARLES EDWARD	28 Victoria Street, S.W
	1904 Jan. 12.	MASTERMAN, SIDNEY WILLIAM	Royal Survey Dept., Bangkok, Siam.
	1896 May 5.	MATHER, SAMUEL	Victoria Road, Surbiton.
m ✠	1896 Dec. 1.	*MATHESON, EDWARD EWING ..	Carrington, Diamond Street, Saltburn-by-the-Sea.
	1892 May 24.	MATHEW, CHARLES	Boro' Surveyor, Ryde, I.W.
	1900 Feb. 6.	MATHEWS, CHARLES JAMES ..	Dept. of Mines, Boiler Inspection Branch, Perth, Western Australia.
	1893 Jan. 10.	MATHEWS, GEORGE SOMERS ..	District Council, Dorking.
	1902 Dec. 2.	*MATHIESON, JAMES GRAY ..	Bryn Coed, Crescent Road, Chingford.
	1895 Dec. 3.	*MATTHEWS, ARTHUR BRINCKEN, B.A. (*Cantab.*)	24 Sistova Road, Balham, S.W.
	1893 Dec. 5.	*MATTHEWS, JAMES NEWSOME ..	Boro' Engineer's Office, Salford.
	1877 Mar. 6.	*MATTHEWS, WILLIAM MACDONALD	22 Broadwater Down, Tunbridge Wells.
	1904 Apr. 12.	MATTINSON, HENRY	55 Piccadilly, Manchester.
	1888 May 1.	*MATTOS, ALVARO GOMES DE ..	98 Rua da Saude, Rio de Janeiro.
	1903 Feb. 3.	MAUGHAN, NICHOLAS	Municipal Offices, Bombay.
	1894 Mar. 6.	MAULDIN, PAMPLIN JOHN ..	99 St. Leonards Road, Hove.
	1902 Jan. 14.	*MAURICE, CHARLES JAMES KINDERSLEY	Inspector of Roads and Bridges, Pretoria, Transvaal.
	1894 May 22.	*MAWSON, MATTHEW	87 Sternhold Avenue, Streatham Hill, S.W.
	1885 Apr. 14.	*MAXTED, GEORGE VINCENT ..	St. Laurence, Cliff Lane, Hornsea, Yorks.
	1902 Apr. 8.	MAXWELL, JAMES THOMSON, B.Sc. (*Edin.*)	East Indian Ry., Calcutta.
	1900 Mar. 6.	MAXWELL, WILLIAM HENRY ..	Town Hall, Tunbridge Wells.

	Date of Election.	Associate Members.	
	1876 Mar. 7.	May, James George	72 Bensham Manor Road, Thor Heath, S.E.
	1892 May 3.	*May, John	Newlands, Copers Cope R Beckenham.
	1884 May 27.	May, Thomas	Gasworks, Richmond, Surrey.
	1890 Jan. 14.	*May, Walter Edward	Sandhurst, Marine Drive, Rhyl
	1866 Mar. 6.	Mayer, Edward Adolphus Fenwick	
	1893 Jan. 10.	*Mayes, Arthur Ernest	P.W.D., Colombo, Ceylon.
	1899 Dec 5.	*Mayes, George Richard	Wynnstay Collieries, Ruabon.
	1889 Dec. 3.	Maylor, William, Jun.	Hanley Grange, Hanley Ca Worcestershire.
	1890 May 6.	*Maynard, John Clarkson Phillips	Irrigation Dept., Pretoria, Transv
	1893 Jan. 10	Meaby, Michael Charles	88 Chancery Lane, W.C.
	1876 Jan. 11.	Mead, Arthur	1 Florence Villas, Grange R Road, Leyton, E.
	1871 Mar. 7.	Meagher, James Joseph	St. Lucia, West Indies. [House,
	1896 Feb. 4.	Medlicott, John Henry	c.o. Macfadyen & Co., Winche
	1901 Jan. 8.	Megaw, David, B.E. (*Royal*)	County Surveyor's Office, Belfast
	1883 May 29.	Meilbek, Joseph	13 Victoria Street, S.W.
	1894 Mar. 6.	*Meischke-Smith, William, M.Sc. (*Victoria*)	
	1897 Apr. 6.	*Meldrum, James	Shire Engineer, Numurkah, Victo
	1893 May 16.	Mellor, Thomas Edward Wheatley	Withington, Boyne Park, T bridge Wells.
	1894 Feb. 6.	Melvill, Edward Harker Vintcent	Box 719, Johannesburg, Transva
	1895 May 21.	Mendonca, Bianor Silvano de	Escriptorio da Linha, E. de Central, Rio de Janeiro.
	1899 Apr. 11.	Menmuir, Robert William	Town Hall, Woodstock, Cape Colo
	1874 Feb. 3.	Menzies, John	Menai Bank, Carnarvon.
	1883 Dec. 4.	*Mercer, George Barker	38 Chatham Street, Liverp (Arrenpee, Liverpool.)
	1889 Dec. 3.	Mercer, William Alexander	85 London Wall, E.C. (Fly London. London Wall, 406.)
	1893 May 2.	Mercieca, Vincenzo	San Paolo 232, Valetta, Malta.
	1891 May 5.	Meredith, William Maxse	2 Whitehall Gardens, S.W.
	1898 Dec. 6.	Merricks, Frank	5 & 6 Great Winchester Street, E (Docimology, London.)
	1891 Apr. 7.	Messenger, Thomas	Greeba, Matham Road, E. Molesey
	1895 Apr. 2.	Messer, William Alfred Sabine	9 Cambridge Road, Lee, S.E.
	1892 Feb. 2.	Metcalf, John William	Town Surveyor, Newmarket.
m ✠	1888 May 15.	*Metcalfe, Arthur Wharton	Director of Works Dept., Admiral Northumberland Avenue, W.C.
	1896 Dec. 1.	Metzger, Gustavus Ferdinand	3 York Street, Manchester.
	1901 Feb. 5.	Meyrick, William Henry	Engineer's Office, L. & S. W. R. Waterloo, S.E. [(C
	1897 Mar. 2.	Michael, Frederick	Tarapaca Waterworks Co., Iquiq
	1889 Jan. 8.	*Middlemist, Henry Ward	F. I. Middlemist, Honiton Sch Honiton, Devon.
	1900 Dec. 4.	Middleton, John Harrison, B.A.I. (*Dubl.*)	170 Pembroke Road, Dublin.
	1892 Feb. 2.	Middleton, Richard Henry	Borough Engineer, Walsall.
m	1899 Dec. 5.	*Middleton, William	Christy Brothers and Middle Chelmsford.
	1892 Dec. 6.	Milbourne, Robert John	Muxton, near Newport, Shrops
	1893 Mar. 7.	*Mildred, Charles	Arbuthnot & Co., Madras.
t ✠	1902 Apr. 8.	*Millar, Alexander	17 Victoria Street, S.W.

Date of Election.	ASSOCIATE MEMBERS.	
1904 Jan. 12.	*Miller, Andrew	Hallside, Newton, Glasgow.
1892 Dec. 6.	Miller, Ernest	The Cottage, Berkeley Avenue, Nottingham.
1893 May 2.	Miller, Harry William ..	Cunningham & Gearing, Atlas Works, Bree St., Cape Town, C.C.
1883 Feb. 6.	Miller, Henry	Surveyor, Felling, co. Durham.
1892 Dec. 6.	*Miller, Henry Morley ..	3 Grassendale Rd., Cressington, Liverpool.
1894 Dec. 4.	Miller, John Ezra	17 Fawcett Street, Sunderland.
1892 Dec. 6.	*Miller, Robert Faulds ..	109 Bath St., Glasgow.
1894 May 1.	*Miller, William Akerman ..	Colonial Engineer, Dominica.
1881 Dec. 6.	Millhouse, William	Waterworks, Scarborough.
1895 May 5.	Milling, Hugh	Roseneath, Malahide.
1895 May 21.	Millner, William James ..	D.P.W., Newcastle, N.S.W.
1890 Apr. 1.	Mills, Arthur Edwin	Marietta, Sandycove, co. Dublin.
1893 Dec. 5.	Mills, Charles Walter ..	F. C. del Sud, Buenos Ayres. [S.S.
1898 Dec. 6.	Mills, Frank	District Ry. Engineer, Taipeng, Perak,
1903 Apr. 7.	Mills, George Hemingway ..	Nurney, Glenagarey, co. Dublin.
1892 Dec. 6.	*Mills, George Pilkington ..	The Woodlands, Beeston, Notts.
1885 Dec. 1.	*Mills, John Charles	King, King & Co., Bombay.
1884 Feb. 5.	*Mills, William Burton Saville	S. E. & C. Ry., Swanley.
1894 Dec. 4.	Milner, Charles Siddall ..	17 Victoria Street, S.W.
1900 Dec. 4.	*Milner, Harold Wood, M.Sc. (*Victoria*)	The Mount, Malton, Yorks.
1888 Dec. 4.	*Milnes, George Percival ..	Town Surveyor, Stroud, Glos.
1881 Apr. 5.	Minchin, John Birch	Oruro, Bolivia, *viâ* Panama.
1893 Jan. 10.	Mitchell, Ernest Herbert ..	c.o. Jessop & Appleby Bros., 22 Walbrook, E.C.
1902 Dec. 2.	Mitchell, James	Tees Conservancy, Middlesbrough.
1901 Apr. 2.	Mitchell, Lewis	Peel Chambers, Market Place, Bury, Lancs.
1888 May 15.	Mitchell, Thomas Wilfred Howe	Mining Offices, Eldon St., Barnsley.
1891 Jan. 13.	Mitcheson, Percy Edward	Durban, Natal.
1895 Mar. 5.	Mitra, Rajesvara, B.A. (*Calcutta*)	P.W.D., Nagpur, C.P., India.
1882 Dec. 5.	Mitre y Vedia, Emilio ..	Buenos Aires.
1896 Apr. 14.	Mittelhausen, Charles Julius Alfred	19 St. John's Park, Blackheath, S.E
1896 May 19.	Mitton, Arthur Dury ..	The Mount, Alderley Edge, Cheshire.
1900 Feb. 6.	*Moberly, James Edward ..	The Grove, Winthorpe, Newark.
1904 Apr. 12.	Moffet, James Scott Duncan	96 Deeplish Road, Rochdale.
1883 May 29.	Molecey, Charles Simpson Twigge	Nelson's Wharf, Lambeth, S.E.
1881 May 31.	Moline, William	19 The Avenue, Clifton, Bristol.
1896 Dec. 1.	*Moller, Warden Appleby ..	Newchwang, China.
1904 Jan. 12.	Mollison, Hector Alexander, B.Sc. (*Glas.*)	30 Balshafray Avenue, Partick, Glasgow.
1895 Dec. 3.	Molloy, Harry James	W. Watson & Co., Bombay.
1902 Feb. 4.	*Molony, Frederick Arthur	Bengal-Nagpur Railway, Calcutta.
1883 Feb. 6.	Molony, John Storan, M.A.I. (*Dubl.*)	Pioneer Mill Co., Lahaina, Maui, Hawaiian Islands.
1902 Dec. 2.	Molyneux, Thomas	Waterworks Office, St. Peter's Square, Stockport.
1880 May 4.	*Monckton, Marmaduke John	c/o H. S. King & Co., 65 Cornhill, E.C.
1904 Apr. 19.	*Monckton, Oliver Paul, B.A. (*Cantab.*)	Laundimer House, Oundle.
1894 Dec. 4.	*Moncur, George, B.Sc. (*Edin.*)	G. N. of Scotland Ry., Aberdeen.
1886 Feb. 2.	Moncur, James	Chief Surveyor of Roads, Stafford.

Date of Election.	ASSOCIATE MEMBERS.	
1893 Dec. 5.	MONCUR, JOHN WILLIAM ..	Borough Engineer, Sunderland
1898 Apr. 5.	MONEY-KENT, JULIAN MONEY VERNON	Lime Tree House, Twicken S.W.
1892 Apr. 5.	MONIES, ALFRED	Grindlay & Co., Calcutta.
1900 Dec. 4.	*MONK, JAMES EDMONSON, B.Sc. (*Victoria*)	Grindlay & Co., Calcutta.
1896 May 5.	MONKHOUSE, HAROLD JOHN	London & County Bank, Hastin
1904 Jan. 12.	*MONRO, ROBERT GODFREY, B.A. (*Cantab.*)	Caerphilly, S. Wales.
1886 Apr. 6.	MONSON, HENRY	7 Anson Road, Tufnell Park, N
1896 Dec. 1.	*MONTAGU, DROGO	Supt. of Telegraphs, Colombo, Ce
1899 Apr. 11.	MONTGOMERY, HERBERT ELPHINSTONE	Fairfield, Darlington.
1903 Apr. 7.	MOON, EDWARD MERCER ..	H.M. Dockyard, Hong Kong.
1895 Dec. 3.	*MOON, EDWIN JOHN	A. Krauss & Son, Lawrence Bristol.
1900 Dec. 4.	*MOON, FREDERICK WILLIAM, B.E. (*Royal*)	Engineer's Office, N.E. Ry., Yo
1897 Dec. 7.	*MOORBY, WILLIAM HENRY, M.Sc. (*Victoria*)	H.M. Dockyard, Devonport.
1894 May 1.	*MOORE, ARTHUR PILCHER FORD	9 Lammas Park Gardens, Ealing.
1894 May 1.	MOORE, CHARLES ELLIOTT, B.A.I. (*Dubl.*)	36 Mutual Buildings, Dur Natal.
1899 Jan. 10.	MOORE, COURTENAY EDWARD, B.A. (*Dubl.*).	D.W. & W. Ry., 1 Westland R Dublin.
1887 Mar. 1.	MOORE, CUNINGHAME WILSON	
1886 Dec. 7.	*MOORE, EDWIN HENRY	20 Baskerville Road, Wandsw Common, S.W.
1894 May 1.	MOORE, ERNEST SHERWOOD WOOLLARD	Electric Construction Corporat Wolverhampton.
1904 Mar. 1.	*MOORE, EVERETT WILLIAM ..	4 Portland Street, Gillygate, Yo
1895 Apr. 2.	*MOORE, GODFREY WILSON ..	South Indian Ry., Cuddalore, Mad
1891 Dec. 1.	*MOORE, KENTISH	
1899 Jan. 10.	*MOORE, SYDNEY WILLIAM, B.A. (*Dubl.*).	Engineer's Office, G. W. Ry., P dington, W.
1888 Mar. 6.	MOORE, WILLIAM JAMES PERRY	147 Queen Victoria St., E.C. (N megged, London. Bank 509.)
1891 Dec. 1.	MOORHEAD, ROBERT BRADSHAW, B.A.I. (*Dubl.*) .	5 Pelsin Road, Shanghai, China.
1902 Dec. 2.	MORCOM, REGINALD KEBLE, B.A. (*Cantab.*)	24 Augustus Road, Edgbaston.
m 1896 Dec. 1.	*MORELAND, RICHARD, JUN.	25 Old Street, E.C.
1892 Feb. 2.	MORGAN, ARTHUR HENRY ..	Mogok, Ruby Mines District, Up Burma.
1899 Jan. 10.	MORGAN, EDWARD LLEWRWG ..	Boro' Engineer, Bolton.
1899 Apr. 11.	MORGAN, FRANK	Norwich Union Chambers, Chamb lain Square, Birmingham.
1889 Dec. 3.	MORGAN, WILLIAM BARLOW ..	Mannamead, Dorchester Rd. W mouth.
1899 Dec. 5.	*MORGAN, WILLIAM RICHARD WILMOT	Star Fort, Matava, Ceylon.
1889 Dec. 3.	*MORIARTY, HENRY ALLASTER ORPEN	Roscrea Priory, Goulburn, N.S.W
1889 Mar. 5.	*MORLEY, JOHN GEORGE	Town Hall, West Ham, E.
1891 Dec. 1.	MORONY, HENRY VEREKER LLOYD, B.E. (*Queen's*). ..	Harbour Engineer, Limerick.
1883 Feb. 6.	MORRIS, EDMUND LEGH	New River Works, Finsbury Park
1900 Apr. 3.	*MORRIS, EDWARD HAROLD ..	Rainhill, Barmburgh, Doncaster
1889 Dec. 3.	*MORRIS, FRANCIS SANDERS ..	4 Trafalgar Square, W.C.
1889 Dec. 3.	MORRIS, PERCY MACDONALD ..	Howick Lodge, Sydney Road, W ton-on-Thames.

	Date of Election.		ASSOCIATE MEMBERS.	
	1901	Dec. 3.	*MORRIS, WILLIAM GERALD ..	47 Spital Street, Dartford.
	1894	May 22.	*MORRIS, WILLIAM VANE	c.o. Mrs. Morris, 11 Park Road, Forest Hill, S.E.
	1899	Dec. 5.	MORRISON, JAMES SMITH ..	11 Beresford Terrace, Dover.
	1898	Apr. 5.	*MORRISON, RALPH PERCY ..	15 Hyde Park Terrace, Leeds.
	1899	Apr. 11.	MORRISON, WILLIAM, B.Sc. (*Glas.*)	7 Maurice Place, Edinburgh.
m	1901	Mar. 5.	*MORTON, ANDREW HOME ..	130 Bath Street, Glasgow.
	1894	Dec. 4.	*MORTON, HUGH JAMES . ..	224 St. Vincent Street, Glasgow. (National 1650 Argyle.)
	1894	Dec. 4.	MORTON, OSWALD GORDON ..	Muswellbrook, *viâ* Sydney, N.S.W.
	1890	Mar. 4.	*MOSS, HENRY ALLAN	c o. H. S. King & Co., 65 Cornhill, E.C.
	1892	Dec. 6.	MOULD, GEORGE ALEXANDER HUTCHINGS	Milliken Bros., 139 Commissioner Street, Johannesburg, Transvaal.
	1894	Dec. 4.	MOULDING, THOMAS	City Surveyor's Office, Exeter.
	1894	Feb. 6.	*MOUNT, JOHN CHAPMAN	Town Hall, Lancaster.
.	1893	Jan. 10.	MOUNTAIN, ARTHUR HENRY ..	Withington, near Manchester.
	1902	Feb. 4.	MOUNTIFIELD, JAMES	142 Balmoral Road, New Brompton, Kent.
	1901	Feb. 5.	*MOWAT, MAGNUS	Millwall Docks, E.
	1902	Apr. 8.	MOYLAN, WILLIAM MORGAN ..	17 Collingham Place, South Kensington, S.W.
	1877	Mar. 6.	*MOYLE, SAMUEL	Towan, Nightingale Road, Guildford.
	1891	Dec. 1.	MUDIE, JAMES ROBERT	24 Forfar Road, Dundee.
	1889	Feb. 5.	*MUIR, EDWARD LESLIE ROBERT	Eng.'s Office, Midland Ry., Derby.
	1890	Dec. 2.	MULLER, JOHAN VIGGO SIGVALD	Newquay, Cornwall.
	1886	Feb. 2.	*MULLIGAN, THOMAS NORTH ..	81 James Street, Dublin.
	1902	Feb. 4.	*MULLINGS, TOM OSBERN	Electric Supply Co., Mansourah, Egypt.
	1885	Feb. 3.	MUMFORD, ARTHUR GEORGE ..	Colchester.
	1885	May 19.	MUNCE, JAMES	City Surveyor's Office, Belfast.
	1904	Apr. 19.	*MUNCE, JAMES STILWELL, B.E. (*Royal*)	67 Conway Road, Plumstead, S.E.
m	1872	May 7.	*MUNDAY, HENRY THOMAS ..	County Council, Spring Gardens, S.W.
	1890	Dec. 2.	MUNN, ROBERT ANDREW ..	5 Winn Road, Southampton.
	1894	Jan. 9.	MUNRO, JOHN MACINTOSH MACKAY	136 Bothwell Street, Glasgow.
	1894	Dec. 4.	MURAKAMI, KIYOICHI	14 Wakamatsu-cho, Osaka, Japan.
	1892	Mar. 1.	MURCOTT, DANIEL	Florence Street, West Perth, W. Australia.
	1867	May 7.	MURDOCH, GEORGE BROWN .	Attonrig, Ferry Rd. West, Edinburgh.
	1902	Apr. 8.	MURPHY, CHARLES FRANKLIN	33 Bridge Street, Morpeth, Northumberland.
	1904	Jan. 12.	*MURPHY, MATTHEW ALEXANDER	Arima, Trinidad.
	1890	Jan. 14.	*MURRAY, CHARLES	
·	1895	Jan. 8.	*MURRAY, GEORGE THOMAS ..	Roads Dept., New Plymouth, New Zealand.
	1883	Feb. 6.	MURRAY, JOHN	Caixa 403, Rio de Janeiro.
	1898	Dec. 6.	MURRAY, LEE, M.C.E. (*Melb.*)	Messrs. Siemens, Johannesburg, Transvaal.
m	1900	Dec. 4.	*MURRAY, ROBERT ALAN ERSKINE	C. S. A. Rys., Braamfontein, Johannesburg, Transvaal.
	1890	Apr. 1.	MURRAY, STEWART BINNY ..	Salem, Madras.
	1886	Dec. 7.	*MUSGRAVE, JAMES	F. C. Oeste. Via y Obras, Buenos Aires.
	1896	Dec. 1.	MUSKER, CHARLES	Tuebrook, Liverpool.
	1896	Dec. 1.	*MYBURGH, HENRY HAWKINS ..	C.C. Pauling & Co., Box 713, Cape Town.
	1887	Mar. 1.	MYLNE, HENRY CHARLES ..	Staverton, Wokingham, Berks.
	1890	Mar. 4.	MYRES, JOHN JAMES	15 Chapel Street, Preston.

	Date of Election.	ASSOCIATE MEMBERS.	
	1891 Mar. 3.	*NAPIER, ARCHIBALD SCOTT ..	King, King & Co., Bombay.
	1888 Jan. 10.	*NAPIER, *Hon.* EDWARD HERBERT SCOTT	Deputy Consulting Engineer f Railways, Lucknow, India.
✠	1899 Dec. 5.	*NARDIN, ERNEST WILLOUGHBY, B.E. (*Sydney*)	Hannan's Star Mine, Boulder Cit Western Australia.
	1903 Mar. 3.	*NARIMAN, RUSTOM KAIKHASRO	Irrigation Dept., Paripat, Punjab.
	1887 Dec. 6.	NASH, ALFRED GEORGE, B.Sc. (*Edin.*)	Greenvale House, Mile Gully P.O Jamaica.
	1904 Apr. 12.	NASH, FOUNTAIN OKEY COLBORNE	Town Hall, Rochdale.
	1895 Mar. 5.	NASH, RICHARD WILKINSON ..	9 Bridge St., Westminster, S.W.
	1893 Dec. 5.	NATH, BISHAMBAR	P.W.D., Punjab.
	1884 May 27.	NATHAN, BENJAMIN ARTHUR..	31 Dorset Square, N.W.
	1904 Apr. 12.	NATHANIELSZ, ARTHUR HOLMAN	Waterworks, 45 John St., Glasgo
	1900 Apr. 3.	NAYLOR, CHARLES HENRY ..	96 Elliscombe Road, Old Charlt Kent.
✠	1892 Dec. 6.	NAYLOR, WILLIAM	8 Garstang Road, Fulwood, Presto
	1900 Dec. 4.	NAZ, JOSEPH LOÏS	Mauritius.
	1878 Feb. 5.	*NEAL, HERBERT	Hill's Cottage, Sidmouth.
	1889 Jan. 8.	NEALL, FRANK FEARNE	Dock Office, Leith, N.B.
	1898 Jan. 11.	NEELY, ALEXANDER JAMES, M.A., M.A.I. (*Dubl.*)	c.o. Grindlay & Co., Parliamen Street, S.W.
	1904 Apr. 12.	NEILL, THOMAS ALBERT ..	47 Disraeli Road, Forest Gate, E.
	1902 Feb. 4.	NEILSON, WILLIAM HARDCASTLE, B.A.I. (*Dubl.*)	Sir John Jackson, Keyham Dock yard Extension, Devonport.
	1895 Dec. 3.	*NELSON, GEORGE	106 High Street E., Wallsend-on Tyne.
	1885 May 5.	NELSON, HENRY	King, King & Co., Bombay.
	1896 Jan. 14.	NETO, JOSEPH GOMES	12 Rua Barao de Victoria, Per uambuco.
	1891 May 5.	NETTLETON, HUGH	Town Hall, Weston-super-Mare.
	1868 Dec. 4.	*NEVILL, PERCY	Harbour Works, Douglas, I. of Man
	1891 May 12.	NEVINS, HUBERT PENROSE ..	Board of Works, Rialto, Collin Street, Melbourne, Victoria.
	1894 Jan. 9.	NEWBIGGING, WILLIAM	5 Norfolk Street, Manchester.
	1899 Apr. 11.	NEWHAM, JOHN THOMAS ..	11 Victoria Street, S.W.
	1895 Dec. 3.	NEWLANDS, ALEXANDER ..	Highland Ry., Inverness.
	1904 Apr. 12.	NEWMAN, HENRY ARTHUR ..	Council Offices, Church End, Finchley, N.
m ✠	1874 May 12.	*NEWMAN, JOHN	Northfleet House, Market Place Brentford.
	1890 May 6.	NEWMAN, JOHN THOMAS ..	Wytefelde, Elsee Road, Rugby.
	1898 May 16.	*NEWMAN, REGINALD WILLIAM	Govt. Irrigation Works, Thebus Cape Colony.
	1891 May 5.	*NEWMARCH, HERBERT SMALES	c.o. H. S. King & Co., Pall Mall, S.W.
	1892 Feb. 2.	*NEWMARCH, LEONARD JOHN ..	Imperial Railways, Tientsin, China.
	1891 Dec. 1.	NEWSON, FREDERIC WALTER ..	Shewan, Tomes & Co., Shanghai.
	1893 May 2.	NEWTON, ARTHUR EDGAR ..	Bombala, Monaro, N.S.W.
	1899 Jan. 10.	*NEWTON, EDWIN BENNETT BRIERLEY	Town Hall, Paddington, W.
	1903 Apr. 21.	*NEWTON, HENRY CECIL EARLE	62 Addison Road, Kensington, W.
	1868 May 5.	NEWTON, SAMUEL BARTON ..	Bhowalee, Naini Tal, N.W.P., India.
	1887 May 24.	NEWTON, WILLIAM JOSEPH ..	Boro' Surveyor, Accrington.
	1902 Dec. 2.	NIAS, CHARLES HENRY	Silver Fir, Church Road, Moseley, Birmingham.
	1877 Feb. 6.	NICE, ALFRED SLATER	Carlton Hall, nr. Newmarket.
	1888 Feb. 7.	*NICHOLL, ARTHUR EDWARD ..	The Rectory, Streatham, S.W.
	1896 Dec. 1.	*NICHOLL, JOHN CLARIDGE ..	Mesne Lea, Parkside Road, West Bowling, Bradford.
	1896 Dec. 1.	NICHOLLS, JOHN SAMUEL ..	335 East India Dock Road, E.
	1890 Dec. 2.	*NICHOLS, ALBERT EDWARD ..	Boro' Engineer, Folkestone. (Surveyor, Folkestone.)

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1904 Apr. 19.	NICHOLSON, JAMES NAPIER ..	3 Cook Street, Liverpool.
1890 Dec. 1.	NICHOLSON, WALTER SERY ..	30 Great George Street, S.W.
1898 Dec. 5.	*NICOLLS, ARTHUR OLIVER ..	Govt. Rys., Box 291, Cape Town, C.C.
✝ 1897 Jan. 12.	*NICOLLS, EDWARD HUGH DYNELEY ..	P.W.D., Cyprus.
1902 Dec. 2.	*NIMMO, JAMES VALENCE, B.Sc. (*Glas.*) ..	13 Southwood Avenue, Highgate, N.
1896 Dec. 1.	NIMMO, WILLIAM HENRY ..	Melbourne Club, Melbourne, Victoria.
1888 Dec. 4.	NISBET, THOMAS ..	Public Works Office, Glasgow.
1902 Apr. 8.	*NIVEN, JAMES JUST ..	108 St. George's Street, Cape Town, C.C.
1897 Apr. 6.	NIXON, FREDERICK ALBERT ..	
1899 Apr. 11.	NOLAN, JOHN JOSEPH ..	Dr. Hatton, 95 Chapel Street, Leigh, Lancs.
1899 Dec. 5.	*NOLAN, THOMAS RICHARD, B.E. (*Royal*) ..	Assam-Bengal Ry., Marlongdisa, India.
1888 Jan. 10.	NORDENFELT, PETER ..	Rue Auber 8, Paris.
1881 Apr. 5.	NORMANVILLE, WILLIAM DE ..	Boro' Engineer, Leamington.
1890 Dec. 2.	NORRINGTON, JAMES PALMER ..	3 Trent Road, Brixton Hill, S.W.
1897 Apr. 6.	NORRIS, WILLIAM ..	Lancashire Steam Motor Co., Leyland.
1885 Feb. 3.	*NORTH, JOHN ..	Oakley House, Eye, Suffolk.
1897 Dec 7.	NORTHCROFT, GEORGE ANDREW	Bloemfontein, Orange River Colony.
1894 Dec. 4.	*NORTON, ARTHUR ..	12 Stanmore Road, Edgbaston.
1901 Mar. 5.	NOWELL, ARTHUR BERRY ..	Dwara - Therria Ry., Ishamati, Sylhet, India.
1893 May 2.	NOWROJI, HORMUSJI, B.E. (*Madras*) ..	Asst. Sanitary Eng. to Govt., Madras
1876 Feb. 1.	NUBAR, H. E. BOGHOS, *Pasha*	State Railways, Cairo, Egypt.
1896 May 19.	NUTTALL, EDMUND ..	The Ash, Seymour Grove, Manchester.
1899 Dec. 5.	*NUTTALL, HERBERT ..	20 Market Street, Bury, Lancs.
1897 Mar. 2.	*NYE, ARTHUR WILLIAM ..	110 Cannon Street, E.C.
1868 Apr. 10.	*NYE, WILLIAM THOMAS ..	Gasworks, Rockhampton, Queensland.

1902 Mar. 4.	*OAKDEN, RALPH, Junr. ..	41 Kirkgate, Newark.
1885 May 5.	OAKES, *Sir* REGINALD LOUIS, *Bart.* ..	Soc. Anonyme La Métallurgique, 1 Place de Louvain, Brussels.
1887 May 3.	*OAKLEY, ALGERNON SEYMOUR BERNARD ..	Barrington Grove, Burford, Oxon.
1896 Feb. 4.	*OAKLEY, ERNEST JOHN ..	Kilburn & Co., 4 Fairlie Place, Calcutta.
1902 Dec. 2.	OAKLEY, HARRY EKERMANS ..	H.M. Dockyard, Malta.
1904 Mar. 1.	OATES, JOSEPH ..	Currey & Tucker, Box 2811, Johannesburg, Transvaal.
m 1902 Jan. 14.	*O'BRIEN, HENRY EOGHAN, B.Sc. (*Victoria*) ..	Exchange Station, L. & Y. Ry., Liverpool.
1900 Dec. 4.	O'BRIEN, PERCY VINCENT	P.W.D., Coolgardie, Western Australia.
1901 Apr. 23.	O'CONNELL, JAMES CHARLES, B.E. (*Royal*) ..	Up Park Camp, Jamaica.
1892 Apr. 5.	O'CONNOR, HENRY ..	Milne & Son, Milton House Works, Edinburgh.
1903 Mar. 3.	*O'CONNOR, RICHARD FRANCIS MARY, B.A., B.E. (*Royal*) ..	C. H. Walker & Co., Harbour Works, Watchet.
1902 Dec. 2.	*ODDIE, PHILIP FRANCIS ..	85 Worple Road, Wimbledon.
1873 Mar. 4.	*ODLING, FRANCIS JAMES ..	Box 314, G.P.O., Melbourne, Victoria.
1894 Dec. 4.	O'DONNELL, JAMES IGNATIUS ..	Glencar, Eglinton Road, Dublin.
1887 Mar. 1.	O'DRISCOLL, FLORENCE ..	2v Bickenhall Mansions, W. (Paddington 994.)

Date of Election.	ASSOCIATE MEMBERS.	
1889 Jan. 8.	*OERTEL, FRED. OSCAR	Allahabad, India.
1902 Mar. 4.	OERTON, FRANK JAMES	Alexandra South Dock, Newpo Mon.
1886 Jan. 12.	*OGILVIE, GEORGE TOD	Fort Jameson, Rhodesia.
1880 Dec. 7.	*OGILVIE, ROBERT CHARLES FREDERICK	Waveney, Upper Long Ditto Surrey.
1859 Jan. 11.	OHREN, MAGNUS	4 Garlies Road, Forest Hill, S.E.
1892 Dec. 6.	OKE, FRANCIS ROBERT	5 Coppenhall Terrace, Crewe.
1865 Apr. 4.	OKES, JOHN CHARLES RAYMOND	131 Verulam Road, St. Albans.
1894 Dec. 4.	OKURA, KUMEMA	Okura & Co., Ginza, Tokio, Japan
1887 Dec. 6.	*OLD, TRENHAM	BayRd.,St.Leonards, Sydney, N.S.\
1900 Feb. 6.	OLDHAM, HUGH	P.W.D., Perth, Western Australia
1895 Dec. 3.	OLDHAM, RICHARD SOULBY ..	New Dock Works, Swansea.
1898 Dec. 5.	OLIVER, ALFRED MARK	98 Lewin Road, Streatham, S.W.
1893 May 2.	OLIVER, GILBERT THOMAS INGLIS	P.W.D., Moulmein, Burma.
1865 Apr 4.	OLIVER, THOMAS	Horsham.
1885 Apr. 14.	OLLIS, WILLIAM BAKER	151 Station St., Burton-on-Trent.
1864 Mar. 1.	ONSLOW, DOUGLAS ARTHUR ..	34 Werter Road, Putney, S.W.
1893 Mar. 7.	OPENSHAW, JAMES	Boro' Engineer's Office, Salford.
1890 Apr. 1.	ORDISH, OWEN	A. B. Debnam, Mt. Pleasant, Pl mouth.
1892 Mar. 1.	*O'REILLY, FRANCIS JOSEPH ..	Cranbrook, East Kootenay, Briti Columbia.
1894 Dec. 4.	*ORFORD, HENRY JAMES	15 Railway Avenue, Maradan Ceylon.
1892 Dec. 6.	ORMEROD, GEORGE HOLT ..	[Assa Assam-Bengal Railway, Lumdin
1885 Feb. 3.	*ORMEROD, RICHARD OLIVER ..	9 Pagoda Avenue, Richmond, Surre
1890 Mar. 4.	ORR, ADOLPHE ERNEST	P.W.D., Lahore, Punjab.
1887 Dec. 6.	ORTON, FREDERICK	Whitchurch, near Cardiff.
1890 Dec. 2.	*OSBORN, ASHBY FREDERICK ..	Roads Office, Cowra, N.S.W.
1887 Dec. 6.	*OSMOND, WILLIAM	8 Wetherby Gardens, Kensingto S.W.
1896 Feb. 4.	O'SULLIVAN, JOHN GABRIEL ..	City Engineer's Office, Dublin.
1887 Dec. 6.	OTAGAWA, MASAYUKI	57 Haramachi I'tchome, Ushigomek Tokio, Japan.
1901 Dec. 3.	OUGH, ARTHUR HENRY	c/o Henry Ough, 64 Basinghe Street, E.C.
1885 Apr. 14.	OUGH, HENRY	64 Basinghall Street, E.C.
1890 Dec. 2.	*OUGHTERSON, ARTHUR	c.o. G. B. Oughterson, 40 Blessin ton Road, Lee, S.E.
1898 Apr. 5.	OUTRAM, FRANCIS DAVIDSON ..	28 Victoria Street, S.W.
1885 Dec. 1.	*OVERTON, FRANK	12 Rectory Road, Beckenham.
1875 Apr. 6.	*OWEN, JOHN ARTHUR	Engineer's Office, Trinity House, E.(
1887 Dec. 6.	OWEN, WILLIAM LAMBDEN ..	Menzies, N. Coolgardie Goldfiel Western Australia.
1902 Apr. 8.	OWENS, JOHN SWITZER, M.D. (*Dubl.*)	Ennerdale, Ford Bridge Road, As ford, Middlesex.
1874 May 12.	OWER, CHARLES	104 Commercial Street, Dundee.
1901 Dec. 3.	*PACK-BERESFORD, ALGERNON DUNBAR	King, Hamilton & Co., Calcutta.
1903 Mar. 3.	*PADDAY, ARTHUR CAMPBELL	P.W.D., Swat River Canal, Mardan India.
1887 Apr. 5.	*PAGE, EDWARD HENRY	11 Castle Street, Cardiff.
1894 Jan. 9.	*PAGE, FRANK WATTS	14 St. Ann's Square, Manchester.
1894 Jan. 9.	*PAGE, SYDNEY ELLIOTT	28 New Bridge St., Blackfriars, E.(
1886 Dec. 7.	PALLANT, THOMAS	Junior Constitutional Club, Picca dilly, W.
1902 Feb. 4.	PALMER, ARTHUR CECIL HUNTER	Govt. Rys., Brisbane, Queensland.

	Date of Election.	ASSOCIATE MEMBERS.	
	1902 Apr. 8.	PALMER, FREDERICK CHARLES RICHARD	21 Blackett Road, Putney, S.W.
	1886 Jan. 12.	*PALMER, THOMAS CASSINET	Beechwood, Moss Lane, Pinner.
	1895 Dec. 3.	PARDOE, JOSEPH CHARLES	Kirklands, Barry, Cardiff.
	1887 May 24.	PARK, CHARLES ARCHIBALD	Wolverton, Bucks.
	1893 Dec. 5.	PARK, JAMES HARVEY WILLIAMSON, B.Sc. (*Edin.*)	Madawachchiya, N.C.P., Ceylon.
	1898 Dec. 6.	PARKER, CHARLES HERBERT	P.W.D., Prome Rd., Rangoon, Burma.
	1883 May 29.	PARKER, HENRY	76 Station Road, South Shore, Blackpool.
	1887 Mar. 1.	PARKER, JOHN	City Surveyor, Hereford.
	1887 May 24.	PARKER, JOHN	107 Bedford Court Mansions, Bedford Square, W.C.
	1886 Dec. 7.	PARKER, JOHN EDWARD	Post Office Chambers, St. Nicholas Square, Newcastle-on-Tyne.
	1899 Dec. 5.	PARKER, PHILIP À MORLEY, B.A. (*Cantab.*), B.C.E. (*Melb.*)	25 Victoria Street, S.W.
	1896 Dec. 1.	PARKER, SYDNEY HYDE	Dibru-Sadiya Ry., Assam.
	1884 Feb. 5.	*PARKES, HENRY	c.o. Parkes & Browne, 52 Lincoln's Inn Fields, W.C.
	1873 Apr. 1.	*PARKES, THOMAS FARMER	Lambeth Waterworks, Brixton, S.W.
	1888 Feb. 7.	*PARKHOUSE, ALFRED WILLIAM LONG	61 Arbuthnot Road, Nunhead, S.E.
	1891 Mar. 3.	PARKIN, FREDERIC WILLIAM	Naylor Bros., Ulleskelf, near York.
m ✠	1889 May 7.	*PARKIN, JOHN HENRY	Gorpley Reservoir, Todmorden.
	1884 Apr. 1.	PARKINSON, HENRY WATERWORTH	Ry. Dept., Brisbane, Queensland.
	1889 Feb. 5.	PARKINSON, JAMES	Ellenby, Wilpshire, Blackburn.
m ✠	1882 May 2.	*PARKINSON, RICHARD MARION	93 Lincoln Road, Peterborough.
	1893 Dec. 5.	*PARKMAN, PHILIP GEORGE WILLIAM	Town Hall, Hounslow.
	1892 Dec. 6.	PARLETT, GODFREY BERNARD	A. Dickinson & Co., Telephone Buildings, Birmingham.
	1894 Dec. 4.	PARR, FRANCIS	Town Hall, Bridgwater, Somerset.
	1879 Dec. 2.	*PARRY, JOSEPH WILLIAM	A. J. Spilsbury, 86 Lyncroft Gardens, Finchley Road, N.W.
	1892 Apr. 5.	*PARRY, RICHARD	82 Victoria Street, S.W.
	1900 Apr. 3.	*PARSONS, THE HON. GEOFFRY LAWRENCE, B.A. (*Oxon.*)	Heaton Works, Newcastle-on-Tyne.
	1888 Jan. 10.	PARSONS, HERBERT JOSIAH	Grindlay & Co., Calcutta.
	1904 Apr. 12.	PARSONS, ROBERT HODSON	35 Bedford Street, Strand, W.C.
	1885 Dec. 1.	PARTINGTON, THOMAS	Outer Barrier Works, Hodbarrow, Millom.
	1886 Apr. 6.	*PARTRIDGE, GODFREY BOWEN	c.o. Mrs. Partridge, 15 Melford Road, Lordship Lane, S.E.
	1892 Feb. 2.	PASSOS, ALEXANDRE PORTELLA	M. F. Gonsalvez, Bahia, Brazil.
	1897 Apr. 6.	PATCH, ALFRED	58 Salford Road, Streatham Hill, S.W.
	1890 Dec. 2.	PATERSON, JAMES DONALD	Engineer's Office, G. W. Ry., Paddington, W.
	1893 Jan. 10.	PATERSON, MATTHEW	Levington, Ellesmere Park, Eccles.
	1892 Jan. 12.	PATERSON, WALTER SAUNDERS	27 St. Stephen's Road, Ealing, W.
	1867 Dec. 3.	PATTERSON, EDWARD CHARLES	103 Church Rd., Upper Norwood, S.E.
	1886 Dec. 1.	PATTERSON, HERBERT CECIL	Jessop & Co., Calcutta.
	1897 Apr. 6.	PATTESON, WALTER	High Greenwood, Heftonstal, Hebden Bridge.
	1885 Dec. 1.	PATTINSON, JOHN SHIELD	Fawcett, Preston & Co., Liverpool.
	1875 Feb. 2.	PATTISON, FREDERICK	130 Hamlet Gardens, Ravenscourt Park, W.
	1885 May 5.	PATTRICK, CHARLES BEAUFOY	Box 4279, Johannesburg, Transvaal.
	1889 Dec. 3.	*PAWLEY, FRANCIS ADOLPHUS	Arkonam, Madras.

Date of Election.	ASSOCIATE MEMBERS.	
1892 Dec. 6.	*PAXON, HAROLD CHARLES ..	Riley, Hargreaves & Co., Singapor S.S.
1897 Apr. 6.	PAYNE, EDMOND WILLIAM ..	M. T. Shaw & Co., 81 Cannon St., E.C
1900 Dec. 4.	PAYNE, HENRY	South African College, Cape Town C.C.
1894 Dec. 4.	PAYNE, PERCY MARRIOTT ..	Holmesdale, The Park, Nottinghan (Holmesdale, Nottingham. 1359.)
1904 Apr. 12.	*PEACE, THOMAS ARTHUR, M.Sc. (*Victoria*)	21 Manilla Road, Clifton, Bristol.
1902 Dec. 2.	*PEACH, CHARLES EDMOND CLEAVER, B.A. (*Cantab.*)	70 Preston New Road, Blackburn.
1900 Apr. 3.	PEAKE, ALGERNON	25 Prospect Road, Ashfield, Sydney N.S. Wales.
1902 Apr. 22.	*PEARCE, EDWARD NATHANIEL	34 Boston Park Road, Brentford.
1900 Apr. 3.	PEARCE, STANDEN LEONARD ..	Corporation Electrical Dept., Dickinson Street, Manchester.
1895 Dec. 3.	PEARSE, ALEXANDER FRANCIS	P.W.D., Eng. Surveys, Perth, W Australia.
1901 Apr. 23.	*PEARSON, GEOFFREY HOPE ..	3 Groundwell Street, Swindon.
1901 Apr. 2.	*PEARSON, HENRY LAWRENCE ..	Box 261, Bloemfontein, Orang River Colony.
1903 Feb. 3.	PEARSON, JAMES DAVIS, B.A., B.E. (*Royal*)	Gya-Katrus Ry., Barano P.O Giridih, Hazaribagh, India.
1893 Feb. 7.	PEARSON, JAMES MONTGOMERIE	5 John Dickie St., Kilmarnock, N.I
1904 Apr. 12.	*PEARSON, KENNETH RAMSAY .	27 Ashworth Mansions, Elgi Avenue, W.
1904 Jan. 12.	*PEARSON, ROBERT JOHN ADDISON	72 Mount Pleasant, Barrow-in-Furness.
1896 Apr. 14.	PECK, HERBERT EDGAR ..	G. M. Sayerman, 88 The Parad Leamington.
1900 Apr. 3.	PECKITT, REGINALD GODFREY, B.A. (*Oxon.*)	Locomotive Department, Egyptia Railways, Boulac, Egypt.
1884 Jan. 8.	*PEDLEY, WILLIAM EVERARD ..	515 Magnolia Avenue, Riversid California, U.S.
1876 Mar. 7.	PEEL, WILLIAM	Knowlmere Manor, Clitheroe.
1904 Feb. 2.	PEET, HASTINGS FITZEDWARD,	City Engineer, Bloemfontein, Orang River Colony.
1890 Dec. 2.	*PEGG, HENRY VILLIERS	The Drift, Ranelagh Rd., Ipswich.
✠ 1896 May 19.	PEIRCE, ARTHUR	Town Hall, Calcutta.
1887 Apr. 5.	*PELLEREAU, HENRY ETIENNE	P.W.D., Hissar, Punjab.
1878 Mar. 5.	*PEÑA, URBANO JOSÉ DE LA ..	8 Recoletos, Madrid.
1884 Feb. 5.	*PENLINGTON, CHARLES BERKELEY	Apartado 82, Bilbao, Spain.
1890 Jan. 14.	*PENN, HARRY	260 South Norwood Hill, S.E.
1887 Jan. 11.	*PENNY, ARTHUR ROBERT ..	Oficina Via y Obras, F. C. del Sur Buenos Aires.
1880 Dec. 7.	*PENNY, SEPTIMUS	24 Fairmile Avenue, Streatham, S.W
1888 Dec. 4.	*PERCEVAL, RICHARD DOUGLAS	Saintfield, co. Down.
1892 Dec. 6.	PERHAM, THOMAS	Marine Dept., Wellington, N.Z.
1885 Jan. 13.	*PERKINS, HUGH FREDERICK ..	Greystone, Bangor, N. Wales.
1892 Dec. 6.	PERKINS, JOHN EDWARD SHARMAN	Park Road, Peterborough.
1898 Apr. 5.	PERKINS, THOMAS LUFF	P. W. D., Hong Kong.
1874 May 5.	PERRETT, EDWARD	151 Bedford Hill, Balham, S.W.
1889 Feb. 5.	*PERROT, SAMUEL DE	Neuchâtel, Switzerland.
1898 Dec. 6.	PERROTT, SAMUEL WRIGHT, B.A.I. (*Dubl.*)	19 Stamford Street, Old Trafford Manchester.
1895 Feb. 5.	PERROTT, WILLIAM GEORGE, B.E. (*Royal*)	Gracefield House, Blackrock, co Dublin.
1889 Dec. 3.	PERRY, ARNOLD HENRY	P.W.D., Cairo, Egypt.
1900 Dec. 4.	*PERRY, GEORGE STEPHENS ..	Ransomes & Rapier, 32 Victoria Street, S.W.
1881 Feb. 1.	PERRY, *Professor* JOHN, M.E. (*Queen's*), D.Sc. (*Royal*), LL.D. (*Glas.*), F.R.S.	Royal College of Science, South Kensington, S.W.

	Date of Election.	ASSOCIATE MEMBERS.	
✠	1886 Dec. 7.	PERRY, THOMAS HOLMES ..	Edgmond Hall, Newport, Salop.
	1898 Dec. 6.	PERRY, WILLIAM RICHARD VICTOR PRITTIE, M.A.I. (*Dubl.*)	G. S. & W. Ry., Limerick.
✠	1895 Dec. 3.	PERRYN, GERRARD HATFIELD	28 Victoria St., Westminster, S.W.
	1901 Jan. 8.	*PETAVEL, JOSEPH ERNEST ..	Physical Laboratory, Owens College, Manchester.
	1900 Apr. 3.	*PETERS, NEIL JAMES	Waterworks Office, Cardiff.
	1900 Dec. 4.	PETTERS, JAMES M'FARQUHAR	P.W.D., Myitkyina, Upper Burma.
	1886 Apr. 6.	*PHELIPS, HENRY VIVIAN MAJENDIE	c.o. H. S. King & Co., Pall Mall, S.W.
	1903 Apr. 7.	*PHELPS, GEORGE INGRAM DE BRISSAC, M.A. (*Cantab.*) ..	23 Augustus Road, Edgbaston.
	1888 Dec. 4.	PHILIP, WILLIAM MARSHALL ..	Philip Bros., Cape Town, C.C.
	1904 Jan. 12.	PHILLIMORE, HUGH BOUCHIER	Kwala Lumpor, Selangore, S.S.
	1885 Dec. 1.	PHILLIMORE, JOSEPH	c.o. Grindlay & Co., Parliament Street, S.W.
	1888 Feb. 7.	PHILLIPS, ARTHUR GAVED ..	11 Essex Villas, Phillimore Gardens, W.
	1891 Feb. 3.	PHILLIPS, ERNEST ALFRED WILLIAM	Thos. Cook & Son, Rangoon, Burma.
	1904 Jan. 12.	PHILLIPS, GEORGE ALFRED ..	County Surveyor's Office, Bridgend, Glamorgan.
	1891 Dec. 1.	*PHILLIPS, HERBERT	48 Edwardes Square, Kensington, W.
	1894 Dec. 4.	PHILLIPS, JOHN	Superintendente de Via Permanente, F. C. Mexicano, Mexico.
	1896 Dec. 1.	PHILLIPS, ROBERT	9 Belgrave Road, Gloucester.
	1895 Feb. 5.	PHILLIPS, ROBERT EDWARD ..	70 Chancery Lane, W.C.
	1902 Dec. 2.	*PHILLIPS, WALTER PATRICK FREAK	3 Grosvenor Road, Coventry.
	1897 Feb. 2.	PHILLIPS, WILLIAM LLEWELYN	N.E.Ry., New Bridge Street Station, Newcastle-on-Tyne.
	1903 Apr. 7.	PHIPPS, FREDERICK REGINALD	Boro' Surveyor, Basingstoke.
	1891 Jan. 13.	PICKARD, ALFRED BARNES ..	5 Madeira Road, Streatham, S.W.
	1891 Dec. 1.	*PICKERING, JOSEPH SPIERS ..	Boro' Engineer, Cheltenham.
	1897 Mar. 2.	PICKERING, SAMUEL ALBERT ..	86 Waterloo Street, Oldham.
	1898 Jan. 11.	PICKERING, WILLIAM TODD ..	Midland Ry., Bugsworth, near Stockport.
	1895 Dec. 3.	PICKLES, GEORGE HENRY ..	Boro' Surveyor, Burnley.
	1896 Feb. 4.	*PIERCE, HUGH, B.A. (*Cantab.*)	Culross, Bassaleg Road, Newport, Mon.
	1891 Feb. 3.	*PIGOTT, FRANCIS JOSEPH ..	P.W.D., Matale, Ceylon.
	1894 Apr. 3.	PILKINGTON, ARTHUR	c.o. H. S. King & Co., 65 Cornhill, E.C.
	1883 Feb. 6.	*PILKINGTON, OLIVER STAINTON	Ivanhoe, Fferm Bach Road, Craig-y-Don, Llandudno.
	1902 Dec. 2.	PILLING, ARTHUR WILLIAM ..	39 Prudential Assurance Buildings, Leeds.
	1904 Jan. 12.	PILLING, HERBERT WYATT ..	39 Prudential Buildings, Park Row Leeds.
	1881 Mar. 1.	PILLOW, EDWARD	Shirehall, Norwich.
	1896 Feb. 4.	*PINCOMBE, WILLIAM EDWIN ..	East Indian Ry., Calcutta.
	1880 Mar. 2.	*PINE, ARTHUR CHILLEY	c.o. Sir C. MacGregor & Co., 25 Charles Street, St. James' Square, S.W.
	1900 Dec. 4.	PINKERTON, EDMUND SUFFERN, B.E., B.A. (*Royal*)	Town Hall, Belfast.
	1879 Feb. 4.	PIPE, SAMUEL MATTHEW ..	13 West Pier, London Dock, E.
	1900 Dec. 4.	*PITCAIRN, FRANCIS BERNARD	Waterworks, Shanghai, China.
	1897 Feb. 2.	*PITTAR, GEORGE FRANCIS ..	17 Mount Ararat Road, Richmond, Surrey.
m ✠	1889 Dec. 3.	*PLATT, JOHN	97 Cedar Street, New York, U.S. (Terneza, New York.)
	1892 Jan. 12.	PLATTS, HENRY CHARLES ..	23 Lime Street, E.C.
	1895 Jan. 8.	PLATTS, THEODORE SERGIUS ..	Waterworks, Odessa, Russia.
	1891 Dec. 1.	POLLITT, ROBERT BARNABAS ..	De Beers Explosives Works, Cape Town, C.C.

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Date of Election.	ASSOCIATE MEMBERS.	
1896 May 19.	*POLLOCK, JAMES, Jun.	1 Langdale Villas, Brownhill Roa Catford, S.E.
1904 Jan. 12.	*POLLOK, JOHN	Charing Cross, Euston & Hampstea Ry., 39 Chalk Farm Road, N.W
1897 Feb. 2.	*POLWHELE, JOHN ARCHIBALD	R. & K. Ry., Budaon, N.P., India.
1882 Dec. 5.	PONT, GEORGE VICTOR	Bengal Nagpur Ry., Raipur, C.P India.
1892 May 3.	POOLE, EDWARD COOPER	5 Portland Street, Southampton.
✠ 1894 Dec. 4.	*POOLE, WILLIAM, Jun., B.E. (*Sydney*)	B.H. Prop'y. Co., Port Pirie, Sout Australia.
1893 Dec. 5.	*POOLEY, HUBERT	Corporation Gas Dept., Stafford.
1881 May 31.	*POPE, FRANCIS JOHN	36 St. Mary's Mansions, Paddington, W
1889 Feb. 5.	POPE, JOSEPH GORDON	Springfield Lodge, The Avenu Grove Park, Wanstead, E.
1892 Dec. 6.	*POPE, THOMAS, Jun.	Wytham, Maze Road, Kew, W.
1889 Dec. 3.	POPKISS, EDWARD PETER	Eng.'s Dept., Govt. Rys., Cap Town, C.C.
1897 Mar. 2.	POPPLEWELL, WILLIAM CHARLES, M.Sc. (*Victoria*)	The Yew, Marple, Stockport.
1889 Feb. 5.	*PORTEOUS, GEORGE WILLIAM	Casa Colon, Huelva, Spain.
1875 Apr. 6.	PORTER, EDMUND VERNON	44 Manor Road, Beckenham, S.E.
1899 Apr. 11.	PORTER, EUSTACE WILLIAM	H.M. Dockyard, Devonport.
1902 Apr. 8.	PORTER, GEOFFREY	Municipal Offices, Worthing.
1890 Dec. 2.	*PORTER, JAMES ROBERTSON	New River Office, Rosebery Avenue E.C.
1900 Jan. 9.	PORTER, RALPH CLASSON, M.Sc. (*Victoria*)	Crosby, Norman Road, Northfield near Birmingham.
1896 Dec. 1.	*PORTSMOUTH, JOHN	12 Little College St., Westminster S.W.
1888 Feb. 7.	PORTUS, ALEXANDER BROWN	Harbour Office, Sydney, N.S.W.
1891 May 5.	POTT, ARTHUR HENRY	69 Victoria Road, Kensington, W.
1876 Apr. 4.	POTTS, BENJAMIN LANGFORD FORSTER	117 Camberwell Grove, S.E.
T t ✠ 1879 May 27.	POTTS, JOHN JAMES	Pier Office, Southport.
1897 Feb. 2.	*POULDEN, GEORGE EDWARD LUTHER	H.M. Dockyard, Gibraltar.
1888 Dec. 4.	POWELL, ARTHUR	3 Unity Street, Bristol.
1881 May 3.	POWELL, EDWARD	Pendennis, Whitchurch, Cardiff.
1885 Dec. 1.	POWELL, HENRY BOLLAND	19 Victoria Street, S.W.
1904 Jan. 12.	*POWELL, HERBERT JAMES BINGHAM	al cuidado del Señor Alcalde de Lima, Peru.
1895 Dec. 3.	POWELL, ROBERT ALBERT	P.W.D., Colombo, Ceylon.
1900 Dec. 4.	POWELL, SIDNEY JOHN	H.M. Naval Yard, Hong Kong.
1887 Mar. 1.	POWER, JOHN MOORHEAD, B.A. (*Cantab.*)	British Consulate, Linares, Spain.
✠ 1880 Dec. 7.	POWLES, HENRY HANDLEY PRIDHAM	90 Oakley Street, Chelsea, S.W.
✠ 1894 Dec. 4.	*POWNALL, JOHN	Idlewild, Westville Road, Thames Ditton, Surrey.
1893 Dec. 5.	PRADO, LEOPOLDO DE ABREU	41 Praia de Cajú, Rio de Janeiro.
1864 Mar. 1.	PREBBLE, CHARLES TREW	Temperley, Hucclecote, Gloucester.
1893 Dec. 5.	*PREBBLE, ERNEST	L. & N. W. Ry., Engineer's Office, Crewe.
1903 Apr. 7.	*PRECHOUS, ROBERT	Admiralty Extension, Keyham, Devonport.
1897 Apr. 6.	*PREECE, WILLIAM LLEWELLYN	Bryn Helen, Woodborough Road, Putney, S.W.
1902 Apr. 8.	PREECE, WILLIAM WALTON	Engineer's Office, G.N. Ry., King's Cross, N.
t ✠ 1876 Dec. 5.	PRELLER, CHARLES SHEIBNER DuRICHE, M.A., Ph.D. (*Leipzig*)	61 Melville Street, Edinburgh.

Date of Election.		ASSOCIATE MEMBERS.	
	1895 Feb. 5.	PRENDERGAST, PATRICK JOSEPH	Borough Surveyor, Athlone, Ireland.
✠	1885 Apr. 14.	*PRENTICE, ERNEST SAMUEL ..	Greystoke, The Avenue, Surbiton.
	1887 Dec. 6.	*PRENTICE, THOMAS THEOPHILUS	Waterworks, Lima, Peru.
	1901 Apr. 2.	PRESCOTT, WILLIAM HENRY ..	712 High Road, Tottenham, N.
	1897 Apr. 6.	PREST, WILLIAM	Rockholme, Ben Rhydding, Leeds.
	1882 Feb. 7.	*PRESTIGE, SYDNEY	Aberdeen House, Blackheath Park, S.E.
	1882 May 2.	PRESTON, EDWARD STUART, M.A. (*Cantab.*)	49 Roland Gardens, S.W.
	1897 Mar. 2.	*PRESTON, FREDERICK KENNERLEY	Bradford Dyers' Association, Well Street, Bradford.
m ✠	1876 May 30.	*PRESTON, SIDNEY, C.I.E. ..	Secy. to Govt., P.W.D., Calcutta.
	1897 Dec. 7.	PRETTY, WILLIAM HENRY ..	Fell Side, Cutcliffe Road, Bedford.
	1898 Dec. 6.	PRICE, ALAN, B.A. (*Dubl.*) ..	15 Macquarie Place, Sydney, N.S.W.
	1893 Feb. 7.	*PRICE, ARTHUR BOYD	Marsland, Price & Co., Nesbit Road, Bombay.
	1897 Jan. 12.	*PRICE, GEORGE JOHN, B.A. (*Dublin*)	
	1897 Apr. 6.	*PRICE, JAMES HENRY	Brompton & Piccadilly Ry., 8 Sherwood Street, W.
	1886 Apr. 6.	PRICE, JOHN	Bureau des Services Sanitaires, Cairo.
	1894 May 1.	PRICE, JOSEPH	125 Bunhill Row, E.C.
	1889 Jan. 8.	*PRICE, PETLEY LLOYD AUGUSTUS	Hayeswood, Pembury, Kent.
	1887 Jan. 11.	PRICE, WILLIAM ARTHUR, M.A. (*Oxon.*)	The Mill House, Broomfield, Chelmsford.
	1891 Feb. 3.	PRICE, WILLIAM EDWARD ..	Gas Works, Hampton Wick.
	1891 Apr. 7.	*PRICE-WILLIAMS, JOHN MORGAN	Tees Valley Water Board, Grassholme, Mickleton, Darlington.
	1891 Jan. 13.	PRICHARD, DAVID	Brithwernydd, Penrhyn Deudraeth, N. Wales.
	1889 Dec. 3.	PRIDHAM, THEODORE	P.W.D., Sydney, N.S.W.
	1904 Apr. 12.	PRIESTMAN, HAROLD, M.Sc. (*Victoria*)	Ashton Grove, Ashton-on-Mersey.
	1891 Mar. 3.	*PRIGG, HENRY VICTOR	6A Courtenay Street, Plymouth.
	1880 Jan. 13.	PRIMROSE, ADAM	Caixa 403, Rio de Janeiro.
	1890 May 20.	*PRINCE, HERBERT WALTER ..	La Guaira Harbour, Venezuela.
	1888 Dec. 4.	*PRINSEP, REGINALD SEYMOUR	Junior Carlton Club, Pall Mall, S.W.
m	1898 Dec. 6.	*PRITCHARD, PHILIP MORRIS ..	United Alkali Co., Widnes.
	1903 Apr. 7.	PRIVETT, JASPER BENJAMIN JOSEPH	28 Gap Road, Wimbledon, S.W.
✠	1889 Dec. 3.	*PROCTER, HERBERT TATHAM ..	32 Market Square, Lancaster.
	1894 Mar. 6.	PROCTOR, HAROLD FARADAY ..	Electric Light Station, Bristol.
	1896 Feb. 4.	PROCTOR-SIMS, ERNEST WILLIAM	P.W.D., Bhavnagar, Kathiawar, India.
	1898 Feb. 1.	*PROES, ERNEST MARINUS ..	P.W.D., Hyderabad, Sind.
	1902 Apr. 8.	PROPHET, JOHN DOWNIE ..	
	1879 Feb. 4.	*PROUSE, OSWALD MILTON ..	Alvington, Slade Road, Ilfracombe.
	1896 Dec. 1.	PROUT, WILLIAM MORRIS ..	Box 1, Knights, Transvaal.
✠	1887 Dec. 6.	*PROVIS, RICHARD	14 Penventon Terrace, Redruth, Cornwall.
	1878 Jan. 15.	PROVIS, THOMAS BAWDEN ..	The Dean, Saltash.
	1886 May 18.	PUCKERING, ROBERT COMINS ..	Britannia Ironworks, Gainsborough.
	1893 May 2.	PUIG DE LA BELLACASA Y SANCHEZ, NARCISO	Serrano 30, Madrid.
m ✠	1892 Jan. 12.	*PULLEN, WILLIAM WADE FITZHERBERT	4 Marlborough Road, Putney, S.W.
	1884 Dec. 2.	PULLON, JOSEPH THOMAS ..	75 Victoria Road, Headingley, Leeds.
	1899 Mar. 7.	PULMAN, THOMAS CHARLES ..	Grindlay & Co., Calcutta.
✠	1883 May 29.	*PUNCHARD, WILLIAM CHARLES	151 Cannon Street, E.C.
✠	1880 May 4.	PURCELL, GERVAISE, B.A. (*Dubl.*)	412 Wilcox Building, Los Angeles, Calif., U.S.

Date of Election.	ASSOCIATE MEMBERS.	
1899 Jan. 10.	*Purser, Walter Bishop ..	4 St. Peter's Hill, Grantham.
1904 Apr. 12.	Purves, Thomas Jolly ..	45 Coleraine Road, Blackheath, S.
1893 May 2.	*Putman, William Ernest Young	Boro' Surveyor, Morley.
1885 Apr. 14.	*Putten, Ernest van	Town Hall, Catford, S.E.
1901 Feb. 5.	Pybus, William Henry Lawson	Govt. Rys., Maritzburg, Natal.
1893 Mar. 7.	*Pyke, Lazarus	10 Westbourne Terrace, Hyde Par
1902 Jan. 14.	*Pyne, Albert Periam	Carr Hill House, Gateshead.
1885 Dec. 1.	*Pyne, Herbert Barrington	Piedad 464, Buenos Aires.
1904 Apr. 12.	Quick, Albert Hedley ..	15 Fernholme Road, Nunhead, S.
1895 Dec. 3.	Quodling, William James ..	Railway Construction Works, Gu dagai, New South Wales.
1891 Dec. 1.	Rabadina, Dorabjee Bhikhajee	B. B. & C. I. Ry., Bombay.
1887 Dec. 6.	Radcliff, Edward..	5 Upper Leeson Street, Dublin.
1896 Mar. 3.	Radclyffe, Leslie	35 Queen Victoria Street, E.C.
1897 Apr. 6.	Raddin, George Henry, B.E. (*Royal*)	Woodmancote, Fairfield Road, Sout ville, Bristol.
1889 Jan. 8.	Radford, John Charles ..	163 Upper Richmond Rd., Putney, S.
1884 Feb. 5.	Radford, William Henry ..	Albion Chambers, King Stree Nottingham.
1895 Feb. 5.	Radley, Edward Yelf, B.A. (*Oxon.*)	27 Albert Hall Mansions, S.W.
1879 Mar. 4.	Radley, John Alfred.. ..	G. E. Ry., Thorpe, Norwich.
1898 Dec. 6.	Raff, Alexander Cumming	Railway Dept., Brisbane, Queens land.
1899 Dec. 5.	*Raikes, Hugh Percival ..	14 Francis Road, Edgbaston, Birmingham.
1903 Jan. 13.	*Ramsey, Albert Norman ..	Caledonian Railway, Dock Exte sion Works, Grangemouth, N.B
1892 Dec. 6.	*Ramus, Bertram Edward de Noual, B.A. (*Cantab.*) ..	Playden Rectory, Rye, Sussex.
1896 Dec. 1.	Randall, Augustus Charles	13 Kendal Road, Colchester.
1876 May 30.	*Randell, John William ..	Grove House, Bagley's Lane, Fu ham, S.W.
1894 Feb. 6.	*Ranken, Arthur William ..	Glen Logan, Heathside Roa Woking.
1884 Apr. 1.	*Rankin, George	Table Bay Harbour Works, Cap Town, C.C.
1874 Apr. 14.	Rankine, David	238 West George Street, Glasgow.
WtMm✠ 1892 Dec. 6.	*Ransom, Herbert Byrom ..	Manlove, Alliott & Co., 41 Parli ment Street, S.W.
1890 Feb. 4.	*Ransom, Peter Augustus, B.A. (*Cantab.*)	Grosvenor Lodge, Beckenham, S.E
1896 Feb. 4.	Ransome, Frederick Stanley	Industrial Engineering Co., Newton Hyde.
1894 May 22.	Ransome, John Wilmer ..	Orwell Lodge, Lordship Terrac Stoke Newington, N.
1892 Dec. 6.	Rao, Kekobad Hormasjee ..	14 Bentinck Street, Calcutta.
1892 Dec. 6.	*Raper, John Charles Dodgson	G. I. P. Ry., Jubbelpur, C.P., Indi
1888 Mar. 6.	*Rapley, Frederick Harvey..	Pressed Steel Car Co., 24 Broa Street, New York, U.S.
1892 Dec. 6.	Ratanji, Manackji	Port Trust, Bombay.
1893 Dec. 5.	*Rathbone, Acheson Lyle ..	Oakfield, Penny Lane, Liverpool.
1882 Feb. 7.	*Rathbone, Edgar Philip ..	Box 927, Johannesburg, Transvaal
1886 Jan. 12.	*Rattray, David Campbell ..	L. & Y. Ry., Eng.'s Office, Man [chester]
1898 Apr. 5.	Raven, Vincent	N. E. Ry., Darlington.

Date of Election.		ASSOCIATE MEMBERS.	
t ✠	1890 May 20.	Ravenshaw, Henry Willock	Rutland House, Hanwell, W.
	1886 Dec. 7.	*Raves, Bertram Adams ..	R.E. Office, North Aldershot.
	1895 Apr. 2.	*Raves, Brian Albert .. .	R.E. Office, Archcliffe Fort, Dover.
	1885 Dec. 1.	*Rawson, Frederick Lawrence	3 Budge Row, E.C. (Bank 123.)
✠	1902 Jan. 14.	*Rayner, Edwin Hartree, B.A. (*Cantab.*)	Tiviot Dale, Stockport.
	1891 Dec. 1.	*Rayner, Frank	1 Alexandra Road, Sherwood Rise, Nottingham.
	1904 Jan. 12.	Read, Frank	Public Offices, Pentre, Rhondda, Glam.
	1884 Dec. 2.	*Read, Harry Vaughan Rudston	Broad St. Avenue, Blomfield St., E.C. (Valorem, London. Avenue 562.)
	1881 Feb. 1.	Read, Richard	City Surveyor, Gloucester.
m	1878 May 7.	*Read, Richard John Gifford	1 Great Chapel Street, Westminster, S.W.
m	1882 Feb. 7.	*Read, Robert Henry	Cadogan Ironworks, Lots Road, Chelsea, S.W.
	1891 Feb. 3.	Reade, James Francis	The Parade, Kilkenny, Ireland.
	1871 Apr. 4.	Reade, Thomas Mellard ..	Park Corner, Blundellsands, Liverpool.
	1887 Dec. 6.	Rees, Frederick Howell ..	Govt. Rys., Victoria West, Cape Colony.
	1894 May 22.	Reeson, Joseph Newell	Gas Light & Coke Co., York Road, King's Cross, N.
	1903 Jan. 13.	*Reeves, Richard Eagle ..	40 St. Peter's Square, Hammersmith, W.
	1895 Dec. 3.	Reid, Alexander	W. A. Reid, 6 Golden Square, Aberdeen.
	1892 Dec. 6.	Reid, Andrew	McAlpine & Sons, 188 St. Vincent Street, Glasgow.
	1896 Feb. 4.	Reid, David John	York House, Church Street, Inverness.
	1904 Jan. 12.	*Reid, Harold	26 Bramham Gardens, S.W.
	1894 Dec. 4.	Reid, John Henry Onslow ..	Pauling & Co., Bulawayo, Rhodesia.
	1893 Dec. 5.	*Reid, Robert Newby Hartley	c.o. H.S. King & Co., 65 Cornhill, E.C.
	1881 May 3.	*Reilly, Frederick, F.C.H. ..	Moss Lane, Pinner.
	1878 May 28.	Reincke, Hans Roderich Leopold	2 Laurence Pountney Hill, E.C. (Bank 530.)
✠	1893 May 16.	*Reinhold, Gustave Charles	11 Hervey Road, Blackheath, S.E.
	1903 Apr. 7.	*Renfree, Thomas Rolls ..	Westinghouse Works, Trafford Park, Manchester.
	1882 Mar. 7.	Renwick, Charles	Public Works Offices, Kingston, Jamaica.
	1902 Feb. 4.	Rettie, Archibald Campbell	Nile Reservoir, Assouan, Egypt.
	1893 May 2.	Revill, William Henry ..	Beira Railway, Umtali, Rhodesia.
	1899 Dec. 5.	Reynolds, Charles Hubert ..	Crown Agent's Office, Downing Street, S.W.
	1894 May 1.	Reynolds, Ernest John ..	3 Clarendon Villas, Beaconsfield Road, New Southgate.
m	1894 Dec. 4.	*Reynolds, Frank Paul ..	Senora Donna Cembrano de Ossorio, 358 General Solano Street, San Miguel, Manila, Philippines.
	1898 Dec. 6.	Reynolds, John Francis Jodrell	47 Victoria Street, S.W.
	1901 Mar. 5.	Reynolds, John James	18 Booth Street, Manchester.
	1890 Jan. 14.	*Reynolds, Leslie Hunter ..	Montecillo, Dunedin, N.Z.
	1886 Jan. 12.	*Reynolds, Thomas Blair ..	28 Victoria Street, S.W.
	1900 Dec. 4.	*Rhodes, Ben Albert	Hallas, Kirkburton, Huddersfield.
	1882 Dec. 5.	Rich, Howard	
	1903 Jan. 13.	*Rich, Theodore	104 St. George's Square, S.W.
	1898 Apr. 2.	Richards, Edwin Melville ..	Boro' Engineer, Warwick.
	1893 May 16.	*Richards, Henry Fines ..	Town Hall, Rochdale.

Date of Election.	ASSOCIATE MEMBERS.	
1893 Apr. 11.	RICHARDSON, CECIL	W. Watson & Co., Bombay.
1887 Jan. 11.	*RICHARDSON, GEORGE RICHARD	Dawankuttie, Adelaide Rd., St biton.
1890 Feb. 4.	*RICHARDSON, HARRY	Council House, Handsworth, Staf
1897 Jan. 12.	RICHARDSON, HARRY ALFRED	Elsinore, Heaton, Bolton.
1904 Apr. 12.	*RICHARDSON, HERBERT LINDSLEY, B.A. (*Cantab.*)	Richardson and Cruddas, Bombay
1897 Apr. 6.	RICHARDSON, JOHN WILLIAM MELLING	Waterworks, 52 Balls Road, Bi kenhead.
1893 May 16.	RICHARDSON, WILLIAM ARTHUR	Glen Heather, Dryburgh Road, Pu ney, S.W.
1885 May 5.	*RICKETTS, DASHWOOD POYNTZ	c.o. H.B.M. Consul, Tientsin, Chin
1900 Mar. 6.	*RICKMAN, JAMES, M.A. (*Cantab.*)	14 Walbrook, E.C.
1897 Jan. 12.	RIDLEY, CLARENCE OLIVER ..	8 Great George Street, S.W.
1886 Mar. 2.	*RIDLEY, MARTYN NOEL	11 Dartmouth St., Westminster, S.W
1900 Dec. 4.	RIGBY, ARTHUR BERTRAM ..	9 Holland Park Mansions, W.
1897 Feb. 2.	*RIGBY, EDWARD HULME, B.Sc. (*Victoria*)	Brooklands, Maghull, Liverpool.
1904 Jan. 12.	*RIGG, FREDERICK JAMES	N.E.Ry. Dock Engineer's Offic Hull.
1902 Mar. 4.	*RISHWORTH, FRANK SHARMAN, B.A., B.E. (*Royal*)	Polytechnic School of Engineerin Cairo.
1888 Jan. 10.	RISTORI, EMANUEL JOSEPH ..	66 Victoria Street, S.W. (Ristor London. Westminster 5058.)
1899 Dec. 5.	RITCHIE, EDGAR GOWAR ..	Metropolitan Board of Works, 5(Collins St., Melbourne, Victoria.
1885 Apr. 14.	RITSON, THOMAS NOBLE	1 West Cliff Villas, West Cliff Roa Ramsgate.
1900 Dec. 4.	RIVERS, CHARLES EDWIN ..	Municipal Offices, Harrogate.
1890 Feb. 4.	*ROACH, WILLIAM LLOYD ..	District Council, Tredegar, Mon.
1890 Mar. 4.	*ROBERTS, CHARLES, F.C.H. ..	Nacoochee Hills Gold Mining Co Nacoochee, Ga., U.S.A.
1898 Apr. 5.	ROBERTS, FRANK	Boro' and Water Engineer, Worthing
1896 May 19.	*ROBERTS, GERVASE HENRY ..	Gas Dept., Locomotive Work Horwich.
1897 Mar. 2.	ROBERTS, HAMLET	Waterworks, Ipswich.
1897 Feb. 2.	ROBERTS, JOHN	28 Fisher Street, Swansea.
1892 Dec. 6.	ROBERTS, JOHN BROAD	Box 2015, Johannesburg, Transvaal
1892 Dec. 6.	*ROBERTS, JOHN MARRIS, B.A.I. (*Dubl.*)	G. S. & W. Ry., 5 Alexandr Terrace, Military Rd., Limerick.
1891 Jan. 13.	ROBERTS, LOUIS EDGAR	23 Salisbury Road, Chorlton-cum Hardy, Manchester.
1890 Dec. 2.	*ROBERTS, REUBEN WILLIAM, F.C.H.	Reform Club, Pall Mall, S.W.
1886 Dec. 7.	ROBERTS, RICHARD GABBETT SPIERS	7 Belgrave Place, Richmond Par Clifton, Bristol.
1904 Jan. 12.	*ROBERTS, ROBERT CORYTON ..	Kennedy & Jenkin, 17 Victori Street, S.W.
1893 Dec. 5.	*ROBERTSON, ALEXANDER GORDON	29 Samos Road, Anerley, S.E.
✠ 1899 Dec. 5.	ROBERTSON, ANDREW ROBERT	8 Park Circus Place, Glasgow.
1892 May 3.	ROBERTSON, FULTON, B.Sc. (*Edin.*)	Price, Wills & Reeves, New Dock Works, Bombay.
1891 May 12.	*ROBERTSON, GEORGE THOMPSON, B.Sc. (*Edin.*)	Lautaro Nitrate Co., Taltal, Chile.
1896 May 5.	ROBERTSON, HORACE PATRICK, M.C.E. (*Melb.*)	Box 88, Kalgoorlie, Western Australia.
1904 Apr. 19.	ROBERTSON, JOHN KERR	121 St. Vincent Street, Glasgow.
1880 Dec. 7.	*ROBINS, EDWARD	c/o H. P. Becher, 26 Bedford Row W.C.
1894 Feb. 6.	*ROBINS, FREDERICK SANDERSON	5 Horncastle Road, Boston, Lincs
1888 Dec. 4.	ROBINS, WILLIAM HENRY ..	82A New Street, Birmingham.

Date of Election.	ASSOCIATE MEMBERS.	
1890 Mar. 4.	ROBINSON, ARTHUR SAMUEL FRANCIS	The White House, Barsham, Beccles.
1892 Dec. 6.	ROBINSON, ERNEST GEORGE ..	F. C. del Sud, Casa Amarilla, Buenos Aires.
1894 Feb. 6.	ROBINSON, FREDERICK FOLEY	1 Telford Avenue, Streatham Hill, S.W.
1904 Apr. 12.	ROBINSON, HERBERT	Redpath, Brown and Co., Riverside Works, East Greenwich, S.E.
1880 Dec. 7.	ROBINSON, HUGH CECIL	35 St. James' Place, S.W.
1887 Feb. 1.	ROBINSON, JAMES	P.W.D., Bhagulpore, Bengal.
1882 Dec. 5.	*ROBINSON, JOHN NEWMAN ..	B. & N. W. Ry., Saidpur, N.W.P., India.
1895 Feb. 5.	*ROBINSON, JOSEPH PETER ..	8 Trafalgar Rd., Birkdale, Southport.
1895 Dec. 3.	*ROBINSON, KEITH	Parliament Mansions, Victoria St., S.W.
1896 Dec. 1.	ROBINSON, LEIGH	
1904 Jan. 12.	*ROBINSON, RALPH	E. Nuttall & Co., Box 1597, Cape Town, C.C.
1883 Dec. 4.	*ROBINSON, RICHARD SYER ..	6 Josephine Avenue, Brixton Hill, S.W.
1882 May 2.	ROBINSON, WILLIAM FLETCHER	Golding, Upper Promenade, Colwyn Bay.
1902 Dec. 2.	*ROBINSON, WILLIAM HUBERT ..	Skiddaw Grove, Keswick.
1899 Jan. 10.	ROBINSON, WILLIAM PAGE ..	31 High Street, Skelton-in-Cleveland.
1904 Apr. 12.	*ROBSON, THOMAS	53 Camborne Grove, Gateshead.
1896 Feb. 4.	ROBSON, THOMAS PEARSON ..	St. Bedes, Hermon Hill, S. Woodford.
✠ 1898 Dec. 6.	ROCHE, EDWARD RICHARD, B.A.I. (*Dubl.*)	Clifton House, Portland Avenue, Exmouth.
1888 Dec. 4.	ROCHFORT, JAMES	Napier, N.Z.
1897 Dec. 7.	RODDA, JOSEPH TONKIN ..	Woodbank, Grove Road, Eastbourne.
1885 May 19.	*RODEN, HORACE HASSALL ..	58 Pennsylvania Road, Exeter.
1901 Dec. 3.	*RODWELL, FREDERICK JOHN ..	41 Prudential Buildings, Leeds.
1900 Dec. 4.	ROE, RICHARD DARTNELL TENNANT	Oficina Compañia, Zapiga, Iquique, Chili.
✠ 1900 Dec. 4.	*ROGERS, ARTHUR EDWARD, B.A. (*Oxon.*)	11 Ennismore Gardens, S.W.
1895 Jan. 8.	*ROGERS, GEORGE SAMUEL WYON	R. E. Office, Tidworth House, near Andover.
1893 Dec. 5.	ROGERS, JOHN	A.M.P. Chambers, Christchurch, N.Z.
1891 Dec. 1.	ROGERS, OLIVER HERBERT ..	Eng.-in-Chief's Office, Adelaide, S. Australia.
1888 Dec. 4.	ROGERS, RALPH BARON, M.A. (*Oxon.*)	Hexworthy, Launceston, Cornwall.
1902 Apr. 8.	ROGERSON, ALBERT CHORLEY ..	Claremont, Curzon Avenue, Victoria Park, Manchester.
1891 Feb. 3.	*ROGERSON, JOHN EDWIN, B.A. (*Cantab.*)	Croxdale Hall, Durham.
1902 Jan. 14.	ROGET, SAMUEL ROMILLY, M.A. (*Cantab.*)	Falkland House, Cheniston Gardens, Kensington, W.
1890 Apr. 1.	RÖHE, CHRISTIAN HEINRICH ..	Campinas, Estado de Sao Paulo, Brazil.
·1872 May 14.	ROMAÑA, EDWARD L. DE ..	G. Stafford & Co., Arequipa, Peru.
1878 Mar. 5.	ROMANES, GEORGE	Craigknowe, Slateford, N.B.
1899 Mar. 7.	ROOKE, THOMAS	c.o. Town Clerk, Town Hall, Sydney, N.S.W.
1900 Jan. 9.	*ROOTS, NEVILLE	47 Primrose Hill, Tonbridge.
1886 Apr. 6.	*ROPER, JOHN SIMPSON	32 Market Square, Lancaster.
1903 Apr. 7.	ROSE, CECIL GUY	Rayners, Penn, Bucks.
1888 Jan. 10.	*ROSE, GEORGE PRINGLE, C.I.E.	c.o. H.S. King & Co., Pall Mall, S.W.
1886 Apr. 6.	ROSE, JAMES WILMOT ANDREAS	Central South African Rys., Pretoria, Transvaal.
1900 Apr. 3.	ROSENBUSCH, GILBERT	5 Lee Terrace, Blackheath, S.E.
1904 Jan. 12.	*ROSENTHAL, FREDERICK MICHAEL BARBAKEL	H.H. the Nizam's State Ry. Co., Secunderabad, India.

	Date of Election.	ASSOCIATE MEMBERS.	
	1902 Feb. 4.	*ROSEVEARE, LESLIE..	City Engineer's Office, Birmingh
	1903 Jan. 13.	*ROSHER, EDWARD MARSHALL	Cape Government Railways, He Junction, Rhodesia.
	1891 Mar. 3.	*ROSS, COLIN JOHN, B.E., B.Sc. (*Edin.*)	Town Hall, North Sydney, N.S.\
	1901 Apr. 23.	*ROSS, DAVID WILLIAM	
	1889 Dec. 3.	*ROSS, FRANCIS EDWARD	39 Halkyn Avenue, Sefton P Liverpool.
	1889 Jan. 8.	ROSS, JOHN CLARK	Town Engineer, Warrnamb Victoria.
	1899 Dec. 5.	*ROSS, JOHN KEITH, M.A., B.Sc. (*Edin.*)	136 St. Thomas Road, Preston.
	1890 Feb. 4.	*ROSS, PERCIVAL	Farfield Mount, Buttershaw, B ford.
	1894 Feb. 6.	ROSS, WILLIAM, B.A.I. (*Dubl.*)	66 North Wall, Dublin.
	1890 Dec. 2.	ROSSBACH, WILLIAM	Harbours & Rivers Dept., Sydi N.S.W.
	1877 Mar. 6.	ROTHWELL, RICHARD MARSHALL	Ellerslie, Summertown, Oxford.
	1896 Jan. 14.	*ROTTER, EDWD. RICHD. ERNEST	Town Hall, Portsmouth.
	1899 Mar. 7.	ROUSE, FRANCIS JAMES	Madras Ry., Nellore, S. India.
	1884 Feb. 5.	ROUSE, HENRY GEORGE ARCHIBALD	Norton, Haslemere Rd., Crouch End
	1890 Apr. 1.	ROUTH, WILLIAM POLE	Oakfield, Southern Hill, Reading
	1894 Dec. 4.	ROVSING, CHRISTIAN MARTIN CRONE, M.A. (*Copenhagen*), *Capt. Siamese R.E. retired.*	141 Ashley Gardens, S.W.
	1878 May 7.	ROWAN, ARTHUR HILL	
✠	1886 Apr. 6.	ROWAN, FREDERICK JOHN ..	71a West Nile Street, Glasg (Barnacles, Glasgow.)
	1900 Feb. 6.	ROWAND, ROBERT	20 St. John's Square, Wakefield.
	1895 Jan. 8.	ROWE, DANIEL	Ivy Villa, Albany Road, Redruth
	1893 Feb. 7.	ROWNEY, GEORGE ANSELM HENRY, B.E. (*Royal*)	D.P.W., Sewerage Branch, Sydn N.S.W.
	1900 Apr. 3.	ROY, THOMAS	Chief Engr., Grand Junction R Cape Town, C.C.
	1893 Mar. 7.	*ROYAL-DAWSON, FREDERICK GEORGE..	Agra - Delhi Chord Ry., Del Punjab.
	1897 Jan. 12.	*ROYLE, FREDERICK MURRAY ..	[Nottingha Milton Chambers, Milton Stre
	1893 Jan. 10.	*ROYLE, STANLEY ARTHUR ..	City Surveyor's Office, Manchest
	1889 Apr. 2.	*ROZARIO, LOUIS CHARLES DO	Rozario & Co., Hong Kong.
	1897 Apr. 6.	RUDGARD, HENRY JOHN.. ..	Eng.'s Office, N.E. Ry., York.
	1900 Dec. 4.	RUDGARD, WILLOUGHBY DOUGLAS	Engineer's Office, N.E. Ry., York
	1901 Dec. 3.	*RUDGE, CHARLES HENRY ..	26 Twyford Avenue, Acton, W.
	1902 Dec. 2.	*RUGG, LEWIS HENRY	19 Dryburgh Road, Putney, S.W.
	1887 Dec. 6.	RUMSEY, HERBERT	Clarendon, Strafford Road, Twick ham.
	1895 Apr. 2.	*RUNDALL, WILLIAM HARRY ..	Taquah & Abosso Gold Mining C Tarkwa, Gold Coast.
W t ✠	1879 Feb. 4.	RUNEBERG, ROBERT..	Bureau Vega, Liteinij pr. 57, Petersburg. (Runeberg, Pete burg.)
	1895 May 21.	RUSHWORTH, JOSEPH	35 Beechfield Road, Harring Park, N.
✠	1887 Apr. 5.	*RUSSELL, ARTHUR JAMES ..	August Strunz, Barranquilla, U Colombia.
t ✠	1892 Feb. 2.	RUSSELL, CHARLES NEWTON ..	29 Southwood Avenue, Highgate,
	1885 Jan. 13.	*RUSSELL, STUART ARTHUR ..	Kingswood, Coventry Road, Ilford,
	1901 Apr. 2.	*RUSSELL, THOMAS WILLIAM ..	Admiralty, 21 Northumberla Avenue, W.C.
	1876 Feb. 1.	*RUSSELL, WILLIAM	9 Victoria Street, S.W.
	1894 May 1.	*RUTTER, CHARLES HERBERT ..	Gas Co., Portslade, Sussex.

Date of Election.	ASSOCIATE MEMBERS.	
1889 Mar. 5.	*Rygate, Philip William, M.A., B.E. (*Sydney*)	322 George Street, Sydney, N.S.W.
1897 Jan. 12.	*Ryman, Frederick Robert	Boro' Surveyor, Stamford.
1899 Apr. 11.	*Ryves, Reginald Arthur ..	Milton Cottage, Harlow, Essex.
1889 Feb. 5.	Sadler, Henry	H.M.Dockyard,Keyham, Devonport.
1892 Dec. 6.	Sadler, William Windham	General Buildings, Perth, N.B.
1894 Feb. 6.	*Sahni, Bhagat Ram	Sirhind Canal, Ludhiana, India.
1904 Jan. 12.	*St. John-Kneller, Oliver Arthur Godfrey	H. M. Dockyard, Devonport.
1896 Feb. 4.	Saise, Alfred John	District Council, Kingswood, Bristol.
1893 Apr. 11.	Salis, Henry Rodolph de ..	Ivy Lodge, Iver Heath, nr. Uxbridge.
1902 Apr. 8.	*Salmon, Charles Emile Herbert	B. & N. W. Ry., Gorakhpur, India.
1904 Apr. 12.	Salmond, Thomas Millar ..	64 Emma Place, Stonehouse, Devon.
1897 Apr. 6.	*Salmond, William..	79 Lynton Avenue, West Ealing, W.
1891 May 5.	*Salter, Arthur Joseph ..	35 Lewisham Rd., Highgate Rd., [N.W.
1890 Jan. 14.	*Saltmarshe, Lionel	Saltmarshe, Howden.
1891 Feb. 3.	*Sample, John Thomas Hornsby	423 Hawthorne Road, Bootle.
1904 Apr. 12.	*Samuel, Randolph John ..	29 Ramsbottom Road, Horwich.
✠ 1899 Dec. 5.	Samuelson, Bernhard Martin	Thos. Cook & Son, Rangoon, Burma.
1902 Jan. 14.	*Sandberg, Christer Peter, Jun.	9 Bridge Street, Westminster, S.W.
1891 Feb. 3.	*Sanders, Evelyn Francis, B.A.I. (*Dubl.*)	Bengal-Nagpur Ry., Sini Station, India.
1887 May 3.	*Sanford, Henry William ..	The Holme, Clifton Hampden, [Abingdon.
1898 Apr. 5.	*Sangster, William Peter ..	P.W.D., Rasul, Gujrat, Punjab.
1902 Feb. 4.	Sano, Tojiro	City Waterworks, Kobe, Japan.
1889 Feb. 5.	*Sant, William Eloin	Wortley, Mais & Sant, Kingston, Jamaica.
1902 Dec. 2.	*Sarge, Robert Arthur.. ..	Naylor Brothers, Ulleskelf, near [York.
1893 Dec. 5.	*Sargeant, Edward Frank ..	Lower Street, Stroud, Glos.
1895 Dec. 3.	*Sargent, Harry Lionel ..	132 Salisbury House, London Wall, E.C.
1885 May 19.	Sartoris, Leonard	6 Ovington Gardens, S.W.
1881 Jan. 11.	*Sauberbgue, Arthur de ..	Dorking, Surrey.
1892 Mar. 1.	*Saunders, Ernest Edward..	Improvements Co., Rio de Janeiro.
1890 Dec. 2.	*Saunders, Frederick Walter Theodor	Government Railways, Cape Town, C.C.
1902 Mar. 4.	*Saunders, Harold Jacob ..	Box 530, Johannesburg, Transvaal.
1880 May 25.	*Saunders, Henry John ..	c.o. John Girdwood, 18 St. Swithin's Lane, E.C.
1902 Dec. 2.	Saunders, James	Imperial Chambers, Newark-on-Trent.
1900 Dec. 4.	Saunderson, Edwin de Bedick, B.A.I. (*Dubl.*)	Lucien Road, Tooting Common, S.W.
1896 Apr. 14.	Saunderson, Frederick ..	Oriel Cottage, Selborne Road, Douglas, Isle of Man.
1892 Feb. 2.	Savage, Edward Ballard ..	Sewerage Dept., Council House, Birmingham.
✠ 1886 Jan. 12.	Savage, Hugh..	Rue Ferdinand Nicolai, Seraing, Belgium.
1895 Dec. 3.	Savage, William	77 Beech Street, Crewe.
1895 Jan. 8.	Savage, William Henry ..	Montfichet, East Ham, Essex.
1882 Feb. 7.	Savioh, Estevao	Via Faentina 133, Florence.
c ✠ 1895 Dec. 3.	*Savile, Leopold Halliday..	Junior Carlton Club, Pall Mall, S.W.
1901 Apr. 23.	*Savile, William Henry Bourchier	Dock Engineer's Office, Cumberland Basin, Bristol.
1889 Dec. 3.	*Savours, William Mathew..	Woodlands, St. Martin's Road, Caerphilly, Cardiff.

	Date of Election.	ASSOCIATE MEMBERS.	
	1887 Mar. 1.	*Saxby, James	Creil, Oise, France.
	1876 Feb. 1.	Saxton, Henry Waring ..	New Plymouth, New Zealand.
	1892 Jan. 12.	Saxton, Thomas Richard ..	43 East Bank, Stamford Hill, N.
	1904 Jan. 12.	*Sayers, Reuben Marchant ..	7 St. Peter's Square, W.
	1895 Dec. 3.	Scaife, Thomas Earle	Irrigation Engineer, Roberts Cape Colony.
	1894 Dec. 4.	Scharschmidt, Samuel Thompson	Hanbury, Shooter's Hill, Jamaica
	1892 Mar. 1.	Schéle, Ernst George Angantyr	Jönköping, Sweden.
	1896 Feb. 4.	Schenk, Charles Edward ..	6 Gwydr Terrace, Swansea.
	1893 Apr. 11.	Schloesser, Robert	Max Gorler, Messrs. Branders Go schmidt, 60 Queen Street, M bourne, Victoria.
	1890 May 6.	Schneider, William Marsland François, M.A. (*Cantab.*)	1 Sydney Terrace, Ryde, I.W.
	1891 Mar. 3.	Schofield, George Andrew	Minna Cottage, Hunstanton.
	1897 Mar. 2.	Schofield, William Higginson	Fairlawn Road, Lytham, Lancs.
✠	1902 Mar. 4.	Scholefield, Russell Scott	Carlton Villas, Hungerford Ro Crewe.
	1887 May 3.	Scholes, Edward Horatio ..	60 Manchester Road, Bury, Lanc
	1886 May 4.	*Schönberg, Alexander Charles	28 Victoria Street, S.W. (Quaya London.)
	1888 May 1.	Schurr, Albert Ebenezer ..	Fry, Miers & Co., 5 Lauren Pountney Hill, E.C.
	1889 Feb. 5.	Schusterschitz, Francisco ..	Belem, Para, Brazil.
	1894 Dec. 4.	*Schwartz, Alfred	Municipal Technical School, Ma chester.
	1893 Dec. 5.	Schwoerer, Emile	Colmar, Alsace, Germany.
	1891 Apr. 7.	*Sclater, Arthur William ..	182 Oxford Street, W.
	1878 May 28.	Sclaverani, Michelangelo ..	Società Nazionale delle Offici Savigliano, Italy.
	1880 Dec. 7.	*Scobie, Mackay John	P.W.D. Secretariat, Rangoo Burma.
	1894 Feb. 6.	*Sconce, Henry Archibald Kerr	Rajputana-Malwa Railway, Jeypo India.
	1877 Dec. 4.	*Scott, Cecil	Municipality, Rangoon, Burma.
	1892 Dec. 6.	*Scott, Cecil Graham	Apperley Cliff, Shanklin, I.W.
	1900 Dec. 4.	Scott, Charles Victor George, B.A.I. (*Dubl.*) ...	P.W.D., Delhi, Punjab.
	1899 Apr. 11.	Scott, Charles William, B.A.I. (*Dubl.*)	The Rectory, Bray, co. Wicklow.
	1882 Mar. 7.	Scott, Donald Albert ..	Beaconsfield House, Hinghar Norfolk.
m ✠	1899 Feb. 7.	Scott, Ernest Kilburn ..	Beesfield House, near Farningha Kent.
	1883 Dec. 4.	Scott, Frank Walter	Woodcliffe House, Burgess Hill, N.W
	1880 May 25.	*Scott, Hugh Hamilton ..	Town Hall, Hove, Brighton.
✠	1886 Dec. 7.	Scott, Jesse French	206 Stanstead Rd., Forest Hill, S.E
	1892 Mar. 1.	Scott, Robert Smith	Town Surveyor, Bishop Stortford.
	1887 Apr. 5.	Scott, William Archibald ..	11 Alexandra Road, Southport.
	1891 Dec. 1.	*Scovell, Charles Thornton Rennie	[Delh
	1895 Dec. 3.	Scratchley, Arthur James	P.W.D., Western Jumna Cana
	1884 Dec. 2.	Scratchley, Herbert Arthur	British Vice-Consul, Philippevill Algeria.
	1895 Apr. 2.	Scratton, Alfred	F. C. del Sud, Buenos Aires.
	1878 Apr. 2.	*Scriven, Charles Walter ..	12 Trossachs Rd., East Dulwich, S.E
	1894 Mar. 6.	Scrutton, Lindsay	918 Hayward Building, San Fran cisco, U.S.
	1904 Jan. 12.	*Seager, James Albert	Charing Cross & City Electric Co Marshgate Lane, Stratford, E.

	Date of Election.	ASSOCIATE MEMBERS.	
m	1894 Feb. 6.	*Sealy-Allin, Auriol	State Engineer, Vizianagram, Madras.
	1895 Apr. 2.	Seaman, Charles Joseph ..	Newton Heath Ironworks, near Manchester.
	1903 Apr. 7.	*Searle, Basil James	49 Carleton Road, Tufnell Park, N.
	1874 Mar. 3.	*Searle, John Coombe	92 Madeley Road, Ealing, W.
	1894 Dec. 4.	*Sears, Robert Humphry ..	East Indian Railway, Calcutta.
	1887 Dec. 6.	Seaton, William Sharpey ..	Montague House, Richmond, S.W. (Seaton, Richmond.)
	1894 Feb. 6.	*Segrais, Paul le Juge de ..	Mare aux Vacoas Waterworks, Curepipe, Mauritius.
✠	1889 Dec. 3.	*Segundo, Edward Carstensen de	267 Dashwood House, New Broad Street, E.C. (Awesome, London. Central 2686.)
	1889 Feb. 5.	Sengoku, Mitsugu	Kiushiu Ry., Moji, Japan.
✠	1884 May 27.	*Sennett, Alfred Richard ..	Seacroft, West Worthing.
	1896 May 5.	Settle, James Ainsworth ..	Boro' Engineer, Heywood.
	1895 May 21.	Settle, Joel	The Hill, Alsager, Stoke-on-Trent.
	1896 Dec. 1.	*Settle, Joseph Risley	H.M. Naval Yard, Gibraltar.
	1893 Dec. 5.	Severn, William Henry ..	9 Bridge St., Westminster, S.W.
	1880 Jan. 13.	*Sewell, Henry de Quincy ..	29 St. Mary St., Toronto, Canada.
	1902 Apr. 22.	*Shackle, Charles Edward	Engineer's Office, G. W. Railway, Paddington, W.
	1886 Apr. 6.	Shackleford, Arthur Lewis	Ampton Lodge, Edgbaston.
	1903 Apr. 7.	*Shackleton, William	Borough Engineer's Office, Hanley.
	1904 Jan. 12.	*Shadwell, Lancelot Horace Augustus	Harbour Department, Durban, Natal.
	1903 Apr. 7.	Shanan, Charles Henry ..	Electricity Works, Dickinson Street, Manchester.
	1882 Apr. 4.	*Shand, James Tilley	75 Upper Ground Street, S.E.
	1893 Jan. 10.	*Sharman, John Roxburgh ..	14 Queen Street, Edinburgh.
	1893 Dec. 5.	*Sharman, Philip Alan	113 Cannon Street, E.C.
✠	1887 Dec. 6.	*Sharp, Archibald, B.Sc. (*Lond.*)	15 Bridge Road, Hammersmith, W.
	1893 Feb. 7.	*Sharp, Frederic David ..	Bryn-clydach, Ynysybwl, Pontypridd.
✠	1879 Feb. 4.	Sharp, William	Invercargill, New Zealand.
	1887 Apr. 5.	Sharpe, Robert	Annaville, Knockbreda Park, Belfast.
	1900 Feb. 6.	Sharpe, Robert John Bevil	36 Lexham Gardens, W.
✠	1900 Apr. 3.	Sharpe, William, B.Sc. (*Glas.*)	Engineer-in-Chief's Office, Government Rys., Pietermaritzburg, Natal.
	1885 May 19.	*Shaw, Edward	Elm Lodge, Bexley.
	1890 Dec. 2.	Shaw, Frederick George ..	11 Neville Court, Abbey Road, N.W.
	1886 Jan. 12.	*Shaw, George Herbert ..	Trinity House, Tower Hill, E.C.
	1890 Apr. 1.	*Shaw, Herbert	Urban District Council, Ilford, E.
	1888 Dec. 4.	Shaw, James Joseph	
	1899 Dec. 5.	*Shaw, John	Engineers' Office, S.E. & C. Ry., Ashford.
	1886 Feb. 2.	Shaw, John Howard	Bracklyn, Poole Road, Bournemouth.
	1897 Apr. 6.	*Shaw, William Barbour ..	224 St. Vincent Street, Glasgow (National, 1650 Argyle).
	1899 Dec. 5.	*Shaw, William Campbell ..	Danesbury, Hinckley Rd., Nuneaton.
	1877 Apr. 10.	*Shaw, William Edwards ..	Albrighton, near Wolverhampton.
	1900 Dec. 4.	*Shawcross, Robert Ellis ..	164 Oakwood Court, Melbury Road, W.
	1904 Feb. 2.	*Shaxby, Richard Underdown, B.A. (*Cantab.*), B.Sc. (*Lond.*)	51 South John Street, Liverpool.
	1895 Jan. 8.	*Sheard, William Curwen ..	Stonelea, Newtown, New Mills, Stockport.
	1882 Dec. 5.	*Shears, James Charles	7 Uxbridge Road, Surbiton.
	1899 Dec. 5.	*Sheffield, Frederick Gerard	Swiftbrook Mills, Saggart, co. Dublin.

	Date of Election.	ASSOCIATE MEMBERS.	
m ✠	1894 Dec. 4.	*Sheffield, George Harrison	15 New Bridge Street, Newcastle-on-Tyne.
✠	1895 Apr. 2.	*Shields, Francis Ernest Wentworth-	Engineer's Office, New Dock Works, Southampton.
	1888 Feb. 7.	Sheldon, Frank	Wells, Somerset.
	1887 Dec. 6.	Sheldon, Percy John	The Chantry, Springfield, Chelmsford.
	1895 May 21.	*Shepherd, Joseph	80 Prince of Wales Mansions, Battersea Park, S.W.
	1903 Jan. 13.	*Shepherd, Joseph	Engineer's Office, N.E. Ry., York.
t ✠	1883 Feb. 6.	Sheppard, Herbert Gurney	Stores Dept., State Rys., Cairo.
	1892 Dec. 6.	Sheppard, Thomas Clive	Obras Publicas, La Paz, Bolivia.
	1888 Jan. 9.	Sherman, Charles Belli Bivar	Holland House, Albury Heath, Guildford.
	1902 Apr. 8.	*Shettle, William Croasdill	Burstall & Monkhouse, 14 Old Queen Street, Westminster, S.W.
✠	1897 Dec. 7.	*Shields, William Herbert, B.Sc. (*Glas.*)	P.W.D., Perth, Western Australia.
	1892 May 3.	Shirlaw, Andrew	Wellington Road, Handsworth, Birmingham.
	1883 May 1.	Short, Francis Job	56 Brook Green, W.
	1896 Dec. 1.	*Shortland, Charles Vincent Nixon	Bengal-Nagpur Ry., Jenapur, Orissa, India.
	1898 Dec. 6.	*Shoubridge, Harry Oliver Baron	Ahmednaggar Irrigation, Nasik, India.
	1884 Dec. 2.	Shuttleworth, Frank Henry	District Council, Littleboro', Manchester.
	1894 Dec. 4.	Sibbald, James	35 Commercial St., Dundee.
	1899 Dec. 5.	Sides, John Francis, B.E. (*Royal*)	G. S. & W. Ry., Inchicore, Dublin.
	1901 Dec. 3.	*Sikes, Louis, B.Sc. (*Victoria*)	Waterworks Office, Harrogate.
	1902 Apr. 8.	*Sikes, Robert Cherry, B.E., B.A. (*Royal*)	Great Western Ry., Gerrard's Cross, Bucks.
	1891 Apr. 7.	*Sillem, William	116 Great Portland Street, W.
	1904 Jan. 12.	*Sillitoe, William Charles	Town Hall, Ealing, W.
	1884 Jan. 8.	Silverthorne, Arthur	5 Victoria Street, S.W.
	1892 Mar. 1.	Simmance, John Frederick	81 Page Street, Westminster, S.W. (Precision, London.)
	1895 May 21.	Simmelkjaer, Sophus	5 Gower Street, W.C.
	1891 May 5.	Simpkins, William, B.Sc. (*Edin.*)	D. & C. Stevenson, 84 George Street, Edinburgh.
	1889 Dec. 3.	*Simpson, Augustus John	Vale Place, Haverhill, Suffolk.
	1895 May 21.	*Simpson, Charles Edward	Wanderer Mine, Selukwe, Rhodesia.
	1888 Feb. 7.	*Simpson, Charles Liddell	101 Grosvenor Road, S.W. (Aquosity, London.)
	1879 Dec. 2.	*Simpson, Fred	Casilla 144, G.P.O., Buenos Aires.
	1889 Jan. 8.	Simpson, Henry Edwin	169 Drakefell Road, Brockley, S.E.
	1899 Dec. 5.	*Simpson, Lightly Stapleton, B.A. (*Cantab.*)	64 Romford Road, Stratford, E.
	1900 Dec. 4.	*Simpson, William	15 Regent Quay, Aberdeen.
	1891 Apr. 7.	Simpson, William Henry	Alliance Chambers, Horsefair Street, [Leicester.
	1891 Dec. 1.	Sinclair, Alexander	Hafod Works, Swansea.
✠	1892 Dec. 6.	Sinclair, John Smart	Town Hall, Widnes.
	1893 Dec. 5.	*Sinnott, Edward Stockley	Western Mail Chambers, Cardiff.
	1897 Mar. 2.	*Sisson, Norman	7 Largo do Viriato, Oporto, Portugal.
	1900 Dec. 4.	Sitwell, John Knightley, B.A. (*Cantab.*)	E. B. Ry., Loco. Dept., Kanchrapara, India.
	1888 Dec. 4.	*Skelton, Robert	Colombo, Ceylon.
	1892 Dec. 6.	*Skinner, Harry Ross	Durban-Roodepoort Mining Co., Johannesburg, Transvaal.
	1891 Dec. 1.	Skipton, John Gervais	Athlone, Ireland.

	Date of Election.	ASSOCIATE MEMBERS.	
	1901 Dec. 3.	*SLADE, CHARLES FELIX ..	Engineer's Office, M. & G.N. Rys., Melton Constable.
	1876 Dec. 5.	SLADE, FREDERICK	Beckford, Tewkesbury.
	1904 Apr. 12.	*SLATER, ERIC ARNOLD	"Athelstan," Maldon Rd., Colchester.
	1896 Feb. 4.	*SLATER, JOSEPH	County Surveyor's Office, Preston.
	1877 Mar. 6.	*SMALL, JAMES MILN	17 Victoria Street, S.W.
	1885 May 5.	SMALLMAN, HENRY FRANCIS ..	Ralston Manor, Mussoorie, India.
✠	1884 Dec. 2.	*SMART, EDGAR	Box 830, Johannesburg, Transvaal.
	1893 Dec. 5.	SMEATON, STIRLING, B.A. (*Adelaide*)	Littlehampton, South Australia.
	1889 Dec. 3.	*SMITH, ALBERT CASSON	Metropolitan Board of Works, Collins St., Melbourne, Victoria.
	1896 Apr. 14.	SMITH, ALEXANDER	F. C. Buenos Aires y Rosario, Rosario, Argentina.
	1876 May 30.	*SMITH, ARTHUR TOULMIN ..	Ludwig & Smith, Miasnitzkaia St., Moscow.
	1888 Feb. 7.	SMITH, BASIL EUSTACE	Ferro Carril, Antofagasta, Chile.
	1891 May 5.	*SMITH, BERTRAM ROBERT ..	R. Smith, Bifrons, Fleet, Hants.
	1894 Feb. 6.	*SMITH, CHARLES CLEMESHA ..	Waterworks, Wakefield.
	1900 Dec. 4.	*SMITH, CHARLES FREDERICK ..	38 Ouseley Road, Wandsworth Common, S.W.
	1904 Apr. 12.	SMITH, EDGAR MARTIN ..	1 Bushnell Rd., Upper Tooting, S.W.
	1897 Jan. 12.	SMITH, EDMUND	The Manse, Balham Park Rd., S.W.
	1886 Dec. 7.	*SMITH, FRANK MARTIN	Roads and Bridges Department, Sydney, N.S.W.
	1900 Apr. 3.	SMITH, GEORGE HENRY, B.A.I. (*Dubl.*)	2 Southey Road, Wimbledon.
	1895 Dec. 3.	SMITH, GEORGE WILLIAM ..	Port Elizabeth, Cape Colony.
	1899 Feb. 7.	*SMITH, GERALD ALFRED ..	37 Dhurrumtollah Street, Calcutta.
	1877 Dec. 4.	SMITH, GUY	Several Farm, Saxstead, Framlingham.
	1897 Apr. 6.	SMITH, HARRY WILLIAM ..	Boro' Engineer, Scarborough.
	1896 Jan. 14.	*SMITH, HENRY VAUGHAN CRAWFURTH	Pembroke Estates Office, 1 Wilton Place, Dublin.
	1902 Apr. 8.	SMITH, HUGH LESLIE	8 St. George's Avenue, Holloway, N.
	1885 Dec. 1.	*SMITH, JAMES CAMPBELL ..	Boro' Surveyor, Bury St. Edmunds.
	1894 Dec. 4.	SMITH, JAMES GOULD	Boro' Surveyor, Guild Hall, Beverley.
	1898 Apr. 5.	SMITH, JOHN WILLIAM	34 Wilfred Street, Derby.
	1891 Feb. 3.	SMITH, RICHARD WILLIAM ..	P.W.D., Colombo, Ceylon.
t ✠	1881 May 3.	SMITH, *Professor* ROBERT HENRY	113 Hopton Road, Streatham, S.W.
	1889 Apr. 2.	*SMITH, ROGER THOMAS, B.Sc. (*Lond.*)	10 Russell Chambers, Bury Street, Bloomsbury, W.C.
	1901 Apr. 23.	SMITH, SYDNEY ARTHUR ..	1 Princess Street, Manchester.
	1895 Jan. 8.	SMITH, T. RIDSDILL	Ravensthorpe, Hessle, Yorks.
	1897 Jan. 12.	*SMITH, THOMAS, B.A.I. (*Dubl.*)	G. N. Ry., Castlewellan, co. Down.
	1883 Feb. 7.	SMITH, THOMAS READER	District Council, Kettering.
	1891 Apr. 7.	SMITH, THOMAS RHYS	150 Broadway, New York, U.S.
	1904 Mar. 1.	*SMITH, THORNTON BROWN ..	66 College Street, Chelsea, S.W.
✠	1881 May 31.	*SMITH, WALTER	King's College, Strand, W.C.
	1891 Feb. 3.	SMITH, WILLIAM	Sewerage Branch, Sydney, N.S.W.
	1886 May 4.	*SMITH, WILLIAM CHARLES ERNEST	Chemins de Fer de la Basse-Egypte, Mansourah, Egypt.
	1904 Apr. 19.	*SMITH, WILLIAM FREDERICK ..	City Engineer's Office, Leeds.
	1890 Dec. 2.	*SMITH-SAVILLE, ROBERT WILLIAM	Borough and Water Engineer, Darwen.
	1892 Apr. 5.	SMYTH, JAMES STEVENSON, B.E. (*Royal*)	Bangkok, Siam.
	1901 Dec. 3.	SMYTH, JOHN MCFALL	Borough Electrical Engineer, Keighley.
	1890 Jan. 14.	SNELL, ALBION THOMAS ..	15 Chatsworth Road, Brondesbury, N.W.

Date of Election.	ASSOCIATE MEMBERS.	
1887 Apr. 5.	SNELL, HARRY	Stanwell Rd., Penarth, Cardiff.
1884 May 27.	*SNELL, HENRY DE MORGAN	20 Cockspur Street, S.W.
1896 Feb. 4.	*SOBBE, FERDINAND AUGUSTUS VON	3 Belvidere Road, Liverpool.
1881 Dec. 6.	*SOLLY, HUBERT LE GAY	Govt. Rys., Cape Town, C.C.
1883 Feb. 6.	SOLOMON, MAURICE	Eng.'s Office, L. B. & S. C. I London Bridge, S.E.
1902 Feb. 4.	*SOLOMON, REGINALD SAUL	Engineer's Camp, Aliwal Nor South Africa.
1898 Dec. 6.	*SOMERS, WILLIAM TOM WOOD	P.W.D., Lahore, Punjab.
1898 Feb. 1.	*SONNEBORN, ALBERT EDWARD HARVEY	23 Minster Road, West Hampste N.W.
1901 Apr. 2.	*SONNENSCHEIN, FREDERIC BOLTON	77 High Street, Marylebone, W.
1897 Feb. 2.	*SOPER, ROBERT LEWIS	Theydon Towers, Epping.
1887 May 24.	SORABJEE, SHAPURJEE	Shapurjee & Ratanshaw, Devonsh Chambers, Bishopsgate St., E.(
1881 May 31.	SOTO, PEDRO NOLASCO DE	Ferro Carril de Zafra, Huelva, Spa
1900 Apr. 3.	*SOUTHEY, FREDERICK	Machribeg, Southend, Cantyre, N
1883 Apr. 3.	SOUTTER, PETER WILLIAM	
1893 Feb. 7.	*SPARKS, IVON ALGERNON	Hillingdene, Gresham Rd., Stain
1897 Apr. 6.	*SPARKS, JAMES NOEL, B.A. (*Cantab.*)	Winchester Ho., Old Broad St.,E
1894 Jan. 9.	*SPENCE, WILFRID L.	British Electric Plant Co.,Alloa,N.
1890 Mar. 4.	*SPENCER, CHARLES TALLENT	The Hall, Harmondsworth, Midd sex. (Spencer, Sipson.)
1890 Dec. 2.	*SPENCER, HENRY BATH	144 St. Vincent Street, Glasgow.
1875 Feb. 2.	SPENCER, HERBERT GEORGE HAMMOND	La Rosario, East Grinstead.
1876 May 30.	SPENCER, JOHN PHILIP	Tynemouth.
1894 May 22.	*SPENCER, LEONARD GRANTLEY PAOLI	Borough Engineer, New Plymout N.Z.
1895 May 21.	SPENCER, THOMAS WILLIAM LORAINE	D.P.W., Casino, N.S.W.
1895 Dec. 3.	*SPENCER-STANHOPE, PHILIP BERTIE, M.A. (*Oxon.*)	Cannon Hall, Barnsley.
1880 Apr. 6.	*SPIELMAN, ISIDORE	56 Westbourne Terrace, W.
1861 Mar. 5.	SPIERS, JOSEPH	9 Marchwood Crescent, Ealing, V
1877 Dec. 4.	SPINDLER, HENRY LEWIS	Port Elizabeth, C.C.
1885 Jan. 13.	SPOONER, HENRY JOHN	309 Regent Street, W.
1900 Mar. 6.	*SPRAGUE, ERNEST HEADLY	180 Regent's Park Road, N.W.
1901 Mar. 5.	*SPRECKLEY, JOHN ALFRED	Boro' Surveyor, Ludlow.
1886 Jan. 12.	*STABLES, EDWARD	c.o. R. H. Harland, 37 Lomba Street, E.C.
1899 Feb. 7.	STACPOOLE, STEPHEN WESTROPP	3A Avenida de la Libertad No Orizaba, Vera Cruz, Mexico.
1891 Dec. 1.	*STAINFORTH, GEORGE MAYNARD	Casilla 473, San José, Costa Rica.
1894 Dec. 4.	STAINTHORPE, THOMAS WILLIAM	P.W.D., Cape Town, C.C.
1894 May 22.	STAINTON, FRANCIS CHARLES	Engineer's Office, S. E. & L. C. & I Rys., London Bridge, S.E.
1895 May 21.	*STALLARD, SIDNEY	Town Hall, Croydon.
1888 Feb. 7.	*STALLIBRASS, EDWARD	27 Cumberland Mansions, Bryansto Square, W.
1896 Feb. 4.	*STAMP, CHARLES	Suptg. Engineer's Office, Dockyar Devonport.
1903 Feb. 3.	*STANDEN, HUGH WYATT	40 Courtfield Gardens, South Ken sington, S.W.
1900 Dec. 4.	STANDFIELD, FRANK	22 Pelham Road, Gravesend.
1903 Feb. 3.	*STANFORD, FREDERICK OWEN	H.M. Dockyard, Simonstown, Cap Colony.
1878 Feb. 5.	STANGER, GEORGE HURST	North Street, Wolverhampton.

Date of Election.	ASSOCIATE MEMBERS.	
1904 Jan. 12.	*Stanger, Reginald Harry Hursthouse	Broadway Testing Works, Westminster, S.W.
1900 Jan. 9.	Stanley, Edward Gower ..	Under Secretary to Government, P.W.D., Simla.
1890 Feb. 4.	Stanley, William Henry ..	Sunnycroft, Trowbridge, Wilts.
1880 Dec. 7.	Stannard, Arthur	25 Charleville Road, West Kensington, W.
1901 Feb. 5.	*Stansfield, Samuel, B.Sc. (*Victoria*)	Newton Heath Ironworks, Manchester.
1902 Dec. 2.	Stanton, Frederick William Schultheiss	James Mansergh & Sons, 5 Victoria Street, S.W.
t ✠ 1894 Feb. 6.	Stanton, Thomas Ernest, D.Sc. (*Victoria*)	National Physical Laboratory, Teddington.
1898 Mar. 1.	*Stanton, Walter Charles ..	Thos. Cook & Son, Bombay.
1892 Feb. 2.	*Staples, Sydney Francis ..	11 Victoria Street, S.W.
1898 Feb. 1.	*Stapleton, Bryan, F.C.H. ..	R.K.M. Ry., Krishnagar, Bengal.
1899 Mar. 7.	*Stapylton, Alan	Assam-Bengal Ry., Badarpur, India.
1868 Dec. 1.	Statham, Edwyn Joseph ..	Cumberland Heights, Parramatta, N.S.W.
1895 Apr. 2.	*Statham, Hugh Worthington	Narrandera, New South Wales.
1894 Dec. 4.	*Statham, William Blackwall	Linde British Refrigeration Co., 35 Queen Victoria Street, E.C.
1888 May 1.	*Statter, John Grice	
1893 Feb. 7.	Stawell, Jonas Molesworth	Ry. Construction Dept., Sydney, N.S.W.
1896 Dec. 1.	Steedman, Henry Percy Gormanston	A. Fredrikson, Almedaal, Gothenburg, Sweden.
1899 Apr. 11.	Steele, William Jones ..	City Engineer's Office, Bristol.
1903 Apr. 7.	Stent, Harold Barclay ..	Norfolk House, Hampton.
1893 Mar. 7.	Stephen, Frederic Wilber ..	Ry. Dept., Petersburg, So. Australia.
1883 May 29.	*Stephen, James Brown	Lancing, Worthing.
1894 May 1.	Stephen, James Henry ..	Leigh, Lancs.
1898 Apr. 5.	Stephens, Charles Thomas ..	Cairns, North Queensland.
1894 Dec. 4.	*Stephens, Holman Fred ..	Light Railway Office, Tonbridge.
1888 Dec. 4.	*Stephenson, Edmund Paley	Town Hall, Llandudno.
1898 Mar. 1.	Stephenson, Edward	Bowes Scott & Western, Broadway Chambers, Westminster, S.W.
1887 May 3.	Stephenson, Joseph Gurdon Leycester	33a Broadway, Hammersmith, W.
1894 Dec. 4.	*Stephenson, Ralph Harry ..	Ferguson & Co., St. Saviour's Road E., Leicester.
1897 Mar. 2.	Stericker, Walter Perchard	Trinity Lodge, Ipswich.
m ✠ 1896 Dec. 1.	*Steven, John Wilson	9 Prince's Terrace, Dowanhill, Glasgow.
1885 May 5.	Stevens, Percival	Port of Spain, Trinidad.
1904 Apr. 12.	Stevens, Theodore	15 Sutton Court Rd., Chiswick, W.
1869 Jan. 12.	Stevens, Warwick Alan ..	237 Southwark Bridge Rd., S.E.
1899 Dec. 5.	*Stevenson, George Harold, B.Sc. (*Edin.*)	Assam-Bengal Ry., Chittagong, India.
1874 Apr. 14.	Stevenson, John	48 Park Place, Cardiff.
1881 Mar. 1.	Stevenson, Sidney Evance ..	Gas Co., Devonport.
✠ 1901 Mar. 5.	*Stewart, Angus Matheson ..	Samana & Santiago Ry., Sanchez, San Domingo.
1894 Feb. 6.	Stewart, John Edwin	River Plate Loan Trust, Avenida de Mayo 645, Buenos Aires.
1892 Apr. 5.	Stewart, John Vaughan ..	Harbour Office, Llanelly.
1899 Dec. 5.	Stewart, Percy Charles ..	L. & N. W. Ry., 9 Walton's Parade, Preston.
1891 Dec. 1.	*Stewart, Thomas	Harbour Works, Port Elizabeth, C.C.
1889 Jan. 8.	*Stickland, Ernest Albert ..	Boro' Surveyor, Windsor.
1892 Dec. 6.	*Stilgoe, Henry Edward ..	Borough Engineer, Dover.
1895 Feb. 5.	*Still, Alfred	Yette Lodge, Ellesmere Park, Eccles.
1893 May 2.	*Still, Percy	Chelsea Electricity Co., 19 Cadogan Gardens, S.W.

	Date of Election.	ASSOCIATE MEMBERS.	
	1890 Dec. 2.	STILWELL, ARTHUR WILLIAM	D.P.W., Sydney, N.S.W.
	1901 Dec. 3.	*STIRLING, GROTE	Engineer's Office, M. & G.N. R Melton Constable.
	1898 Dec. 6.	STIRLING, JAMES	G.N. Piccadilly & Brompton Ry Belgrave Street, King's Cross, W
	1892 Apr. 5.	*STOCKEN, ALFRED LEONARD ..	Lacrois, Fils et Cie., Mazères-sur Salat, France.
✠	1878 Feb. 5.	*STOESS, CHARLES ANTHONY ..	Box 48, Vancouver, British Columb
	1895 Dec. 3.	*STOKER, GILBERT	41 Gonville Road, Thornton Hea
	1889 Jan. 8.	*STOKOE, EDWARD RICHMOND ..	Clevedon House, Woodhall Spa, Lin
	1886 Apr. 6.	*STONE, FRANK HOLMES	G.P.O., Freetown, Sierra Leone.
✠	1873 Mar. 4.	STOOKE, THOMAS SULLOCK ..	Belle Vue, Havelock Road, Shrewsbury.
✠	1896 Dec. 1.	STOTHERD, CHARLES EGREMONT	Jeypore, Rajputana, India.
✠	1901 Dec. 3.	*STOW, GEORGE	Southdown Road, Shoreham.
	1900 Apr. 3.	STRACEY, HERBERT JAMES ..	Western Mail Chambers, Cardiff.
	1874 Feb. 3.	*STRACHAN, JOHN	Craigisla, Penylan, Cardiff.
	1898 Apr. 5.	STRACHEY, RALPH	E.I.Ry., Dinapore, India.
	1888 May 15.	STRAIN, JOHN LOUDON	Court House Chambers, Buxton.
	1879 Feb. 4.	STRAKER, CHARLES EDMUND, M.A. (*Cantab.*)	High Warden, Hexham.
	1895 Dec. 3.	STRAKER, SIDNEY	9 Bush Lane, Cannon Street, E.C
	1904 Jan. 12.	*STRANG, WILLIAM GUTHRIE, B.Sc. (*Glas.*)	Victoria Villas, Stafford Ro Wolverhampton.
	1889 Dec. 3.	STRANGE, ALEXANDER BURROUGHS	c/o Grindlay & Co., Parliam Street, S.W.
	1885 Dec. 1.	STRAPP, WALTER	Rue de Madrid 15, Paris.
	1894 Dec. 4.	*STRIDE, HERBERT WALTER ..	Holmwood, Cossington Road, We cliff, Essex.
	1890 May 6.	*STRINGFELLOW, WILLIAM ..	Urban District Council, Ashbor Derbyshire.
	1869 Feb. 2.	STRONGITHARM, AUGUSTUS HORACE	Barrow-in-Furness.
	1897 Feb. 2.	*STRUBEN, ARTHUR MARINUS ALEXANDER	D.P.W., Pretoria, Transvaal.
	1882 May 23.	STUART, JAMES, M.A., LL.D. (*Cantab.*) ..	24 Grosvenor Road, S.W.
	1898 Feb. 1.	STUART, JAMES	94 Hope Street, Glasgow.
	1901 Dec. 3.	*STUART, JAMES DOUGLAS . ..	A. Scott & Co., Rangoon, Burma.
	1900 Apr. 3.	STUART-MENTETH, WILLIAM FREDERICK	Municipal Engineer, Lahore, Punj
	1899 Dec. 5.	STUBBS, HERBERT EDWARD CRAMPTON	P.W.D., Jhelum Valley Ro Srinagar, Kashmir, India.
	1885 Apr. 14.	STUBBS, JOHN PEMBERTON ..	43 Wroughton Road, Balham, S.
	1883 Dec. 4.	STUBBS, WILLIAM	Municipal Offices, Blackburn.
	1898 Apr. 5.	STUDLEY, SAMUEL HAROLD ..	Water Dept., Town Hall, Sheffield
	1890 Dec. 2.	*SUAREZ, PEDRO	Ingeniero Primero de Caminos, Rib alta, Rio Beni, Bolivia.
	1894 Dec. 4.	SUBRAHMANYAM AIYAR, SUNDARAIYAR ARUMBUR, *Rai Sahib*, B.A., B.E. (*Madras*)	Mayavaram, Tanjore, Madras.
	1894 Jan. 9.	SUGGATE, ALFRED	33 Villa Road, Brixton, S.W.
	1891 Jan. 13.	SUGGATE, FREDERICK CHENERY	Gasworks, Auckland, N.Z.
	1903 Apr. 7.	SULLIVAN, ROBERT JAMES, B.A.I. (*Dubl.*)	4 Moyola Terrace, Lansdowne Ro Limerick.
	1883 Jan. 9.	*SUMMERSCALE, ALFRED	L. & Y. Ry., 23 Walton Par Liverpool.
	1895 Jan. 8.	*SUTCLIFFE, FREDERICK WILLIAM	Oak Hill, Burnley.
	1896 Mar. 3.	*SUTCLIFFE, JOHN	Town Hall, Kennington Green, S.
	1896 Dec. 1.	SUTHERLAND, ALEXANDER CHARLES, M.A., M.C.E. (*Melb.*)	Govt. Mining Engineer's Offic Johannesburg, Transvaal.
	1895 Dec. 3.	*SUTHERLAND, JAMES	P.W.D., Lower Sind Ry., Hyder bad, Sind.

Date of Election.	ASSOCIATE MEMBERS.	
1894 May 22.	SUTHERLAND, JOHN ROBERTSON	45 John Street, Glasgow.
1886 Dec. 7.	SUTTON, JOSEPH WALKER ..	36 Bedford Street, Strand, W.C.
1895 Dec. 3.	SUTTOR, JOHN BLIGH	Commercial Agency, N.S.W. Govt., Kobe, Japan.
✠ 1885 Mar. 3.	*SWAINSON, JOHN HENRY ..	66 Church Street, Egremont, Cheshire.
1899 Dec. 5.	SWARBRICK, ROBERT ALFRED	117 The Avenue, Ealing, W.
1901 Dec. 3.	*SWAYNE, GERALD	Lanesboro', Guildford.
1896 Dec. 1.	SWINBURNE, GEORGE	99 Queen St., Melbourne, Victoria.
1892 Dec. 6.	*SYKES, CHARLES FREDERICK, F.C.H.	King, King & Co., Bombay.
✠ 1888 Dec. 4.	SYKES, CLEMENT MORISORIP ..	State Engineer, Jamnagar, Kathiawad, India.
1888 Jan. 10.	SYKES, EDWARD	DistrictCouncil,Cheadle,Manchester.
1896 Dec. 1.	SYKES, ERNEST	Coniston, Polsloe Park, Exeter.
1897 Jan. 12.	*SYKES, JOSEPH CHARLES ..	21 Ardbeg Road, Herne Hill, S.E.
1892 Mar. 1.	*SYMMONS, PERCY WILSON ..	113 Cannon Street, E.C.
1894 Mar. 6.	SYMONS, DIOGO ANDREW ..	9 Bridge Street, Westminster, S.W.
1890 Mar. 4.	*SYNGE, ROBERT ANTHONY, B.A. (*Dubl.*)	Edward Synge, Estates Office, Kingscourt, co. Cavan.
1888 Dec. 4.	SYSON, ROBERT COCKBURN ..	Leamington Cottage, Bearsden, Glasgow.
1897 Apr. 6.	SZLUMPER, CHARLES DAVID ..	17 Victoria Street, S.W.
1887 Dec. 6.	TAITE, JOHN CHARLES	63 Queen Victoria Street, E.C. (Central 6925.)
✠ 1890 Dec. 2.	TANABE, *Professor* SAKURO ..	Kioto University, Japan.
1882 Dec. 5.	TANDY, JOHN O'BRIEN	4 Wellington Villas, Wellington Square, Crewe.
1886 Dec. 7.	TAPLAY, HERMAN	Ercaldene, Wellington, Salop.
1896 Mar. 3.	*TARGET, FELIX ALEXANDER ..	Primrose Club, Park Place, St. James', S.W.
1901 Dec. 3.	*TARRANT, ERNEST ARTHUR ..	51 Watson Road, Worksop.
1891 Dec. 1.	TATE, HERBERT WILLIAM ..	405 Cheetham Hill Rd., Manchester.
1893 Dec. 5.	TATE, JOHN	6 Victoria Villas, Brookwood, Woking.
1887 Jan. 11.	TATE, WALTER HOWARD ..	Taiping, Perak, S.S.
1893 Dec. 5.	TAYLER, ALEXANDER JAMES WALLIS	77 Victoria Road, Kilburn, N.W.
1896 Dec. 1.	TAYLOR, ARTHUR JOSEPH ..	6 Apsley Crescent, Manningham, Bradford.
1897 Dec. 7.	*TAYLOR, DAVID GUILLAND, B.Sc. (*Glas.*)	D. Craig, Springvale, Prestwick, Ayrshire.
m 1902 Apr. 8.	*TAYLOR, FRANK COSTON, M.A. (*Cantab.*)	State Railways Dept., Cairo, Egypt.
1897 Jan. 12.	TAYLOR, HARRY WILLIAM ..	St. Nicholas Chambers, Amen Corner, Newcastle-on-Tyne.
1885 May 19.	TAYLOR, HENRY	District Council, Clevedon, Somerset.
1899 Apr. 11.	*TAYLOR, JOHN CHARLES, R.N.R.	Port Commissioners' Office, Calcutta.
1904 Feb. 2.	*TAYLOR, JOHN REGINALD, B.A. (*Cantab.*)	11 Vincent Square, Westminster.
1886 Apr. 6.	*TAYLOR, ROBERT CHARLES ..	St. James's Gate Brewery, Dublin.
1886 Jan. 12.	TAYLOR, ROBERT HENRY ..	230 Lewisham High Road, S.E.
1879 Apr. 1.	TEASDEL, JAMES EDWIN	3 Queen Street, Great Yarmouth.
1903 Apr. 7.	*TEDMAN, CYRIL	G.I.P. Ry., Bhusawal, India.
1901 Mar. 5.	*TEMPLE, LEONARD	Fraser House, Forest Gate, E.
1891 May 5.	TEMPLER, CHARLIE LIONEL ..	48 Newbold Road, Rugby.
1886 May 18.	*TEMPLETON, EDWIN ARTHUR SLADE, M.A. (*Dubl.*)	Buckholtz Turbine Syndicate, Winchelsea Road, Harlesden, N.W.

Date of Election.		ASSOCIATE MEMBERS.	
	1897 Apr. 6.	*Terry, Alfred John	Grove Mount, Pudsey.
	1902 Apr. 8.	Thain, William Arthur ..	University College, Cardiff.
	1899 Dec. 5.	Thomas, Arthur Edmund ..	Moa Tin Mine, Moorina, Tasma
	1881 Feb. 1.	Thomas, Charles Henry ..	Brecon & Merthyr Ry., Trede Chambers, Newport, Mon.
	1881 May 31.	Thomas, Charles Neumann ..	The Anchorage, St. James, K Bay, Cape Colony.
	1896 May 5.	Thomas, David Prosser ..	Islwyn House, Llantwit Var Pontypridd.
	1891 Apr. 7.	Thomas, Elijah, *Fleet Eng.* R.N.	Holborn Villa, Sheerness.
	1877 May 29.	Thomas, Herbert Oliver ..	Town Hall, Woolwich.
	1899 Dec. 5.	*Thomas, Hubert Robert, B.Sc. (*Victoria*)	1 Avenue Road, Wolverhampton
	1890 Dec. 2.	Thomas, John	32 Fisher Street, Swansea.
	1896 Dec. 1.	Thomas, John Frederick Ivor	35 Kirkstall Road, Streatham, S
	1860 May 22.	Thomas, Joseph Lee	2 Hanover Terrace, Ladbroke Sq.
	1901 Dec. 3.	Thomas, Orlando Venning ..	P.W.D., Penang, S.S.
	1902 Dec. 2.	*Thomas, Percy, M.Sc. (*Victoria*)	125 Mayfair Avenue, Ilford.
	1901 Apr. 2.	Thomas, Thomas George Howes	Braithwaite, Blenheim Villas, W ton Road, Twickenham.
	1889 Dec. 3.	Thomas, Thomas James ..	Town Surveyor, Ebbw Vale, Mo
	1891 Mar. 3.	Thomas, Trevor Falconer ..	9 Mount Stuart Square, Cardiff.
✠	1889 May 7.	Thomas, William	Perranporth, Cornwall.
	1902 Dec. 2.	*Thomas, William	4 Eton Avenue, Hampstead, N.W
	1887 Jan. 11.	Thomas, William Edmond Clason	Brynhafod, Neath, South Wales.
	1896 Dec. 1.	*Thomas, William Matthews	Staplake Mount, Starcross, Exet
	1887 Dec. 6.	Thomlinson, John Hutton ..	Gasworks, Brisbane, Queensland
	1883 May 29.	Thompson, Albert George ..	4 Strathmore Gardens, Bognor.
	1886 Feb. 2.	*Thompson, George William	8 Belmont Road, Wallington, Sur
	1895 Dec. 3.	*Thompson, John	Rose Hill, Heysham, Morecambe
✠	1894 Dec. 4.	*Thompson, John	Harbour Engineer, Dundee.
m ✠	1883 Feb. 6.	*Thompson, John Augustus ..	9 Billiter Square, E.C.
	1894 Mar. 6.	*Thompson, John Edward Oakes	31 Whitefield Road, Stockton He Warrington.
✠	1893 Apr. 11.	Thompson, Robert William	St. Thomé, Madras.
✠	1904 Apr. 19.	*Thompson, Waude..	Town Hall, Burton-on-Trent.
	1888 May 15.	Thompson, William	1 Great Winchester Street, E.C.
t ✠	1886 Dec. 7.	Thompson, William Mann, M.A., B.E. (*Sydney*)	Tongarra. via Albion Park, N South Wales.
	1894 Feb. 6.	Thomson, Ambrose Hepburn	Court House, Marylebone Lane,
	1889 Mar. 5.	*Thomson, Arthur Sackville	King, Hamilton & Co., Calcutta.
	1900 Apr. 3.	Thomson, George	3 Woodburn Terrace, Morning Edinburgh.
	1901 Apr. 2.	Thomson, Gilbert, M.A. (*Edin.*)	164 Bath Street, Glasgow.
	1904 Apr. 12.	Thomson, Hugh Alexander	2 Grantly Gardens, Shawla Glasgow.
	1889 Jan. 8.	Thomson, James	22 Rutland Square, Edinburgh.
	1871 Apr. 4.	Thomson, John	Grindal Place, St. Bees, Cumb
	1876 May 30.	Thorne, Alfred	7 Carteret Street, Westminster,
	1900 Apr. 3.	Thornhill, Walter Edward	L. & N.W. Ry., Church Road St Garston, Liverpool.
	1879 Apr. 1.	Thornton, Hawthorn Robert	Govt. Rys., Uitenhage, Cape Co
	1904 Apr. 12.	Thornton, Rennie	Boro' Surveyor's Office, South
	1893 Dec. 5.	*Thornton, Stanhope Evelyn	Sanctuary House, Tothill S Westminster, S.W.
	1899 Dec. 5.	*Thornycroft, John Edward	Homefield, Chiswick, W.
	1893 Dec. 5.	*Thorp, Richard Fenwick ..	Munaar, Devikolam P.O., India
	1886 Apr. 6.	*Thorpe, Robert Henry ..	97 Cedar St., New York, U.S. (Th latt, New York.)
	1890 Jan. 14.	Thorpe, William Henry ..	60 Winsham Street, Clapham C mon, S.W.

Date of Election.	ASSOCIATE MEMBERS.	
1902 Feb. 4.	*THRELFALL, HAROLD SPENCER, M.Sc. (*Victoria*)	Admiralty Offices, Keyham Extension, Devonport.
1895 Dec. 3.	THRELFALL, *Professor* RICHARD, M.A. (*Cantab.*)	30 George Road, Egbaston, Birmingham.
1898 Dec. 6.	*THRING, LEONARD GODFREY PINNEY, B.A. (*Cantab.*) ..	Ploneks Hill, Shamley Green, Guildford.
1889 Feb. 5.	*THRUPP, EDGAR CHARLES ..	39 Victoria Street, S.W.
1895 Jan. 8.	*THURSFIELD, FRANCIS	Thursfield & Messiter, Wednesbury.
1880 Dec. 7.	*THWAITE, BENJAMIN HOWARTH	29 Great George Street, S.W. (Calcination, London.)
1889 Dec. 3.	TICKELL, GEORGE TEMPLER ..	P.W.D., Selangor, S.S.
1893 Feb. 7.	TIDD, ERNEST GEORGE	25 Gordon Street, Glasgow.
1890 Dec. 6.	*TIDDEMAN, EDMUND SPENSER	14 Elgin Road, Ilford, E.
1896 Dec. 1.	TIFFIN, THOMAS EDWARD ..	Council Offices, Dartford, Kent.
1867 Dec. 3.	TIJOU, WILLIAM	52 Tavistock Terrace, Upper Holloway, N.
1893 May 16.	*TILL, GUY LAURENCE	City Surv.'s Office, Birmingham.
1891 Dec. 1.	TILLEY, ALBERT	15 Fair Oak Avenue, Newport, Mon.
1889 Apr. 2.	*TIMMINS, ARTHUR	Bridgewater Foundry, Runcorn.
1896 Mar. 3.	TIMMINS, THOMAS	Dorman, Long & Co., Moray St., South Melbourne, Victoria.
1899 Apr. 11.	TIMMIS, EDGAR WILLIAM ..	2 Great George Street, Westminster, S.W.
1890 May 20.	TIMONOFF, *Professor* VSEVOLOD DE	Ministère des Voies de Communication, Fontanka 117, St. Petersburg.
1875 Mar. 2.	*TINTORER GIBERGA, JOSÉ ..	Asalto 12, Barcelona, Spain.
1894 Dec. 4.	*TIPLADY, RICHARD CLEMENT	Demerara Railway, Georgetown, British Guiana.
1893 May 2.	*TIPPETT, ARTHUR MAY	Govt. Rys., Cape Town, C.C.
1900 Apr. 3.	*TIPPETTS, RUSSELL	S. Pearson & Son, Obras del Puerto, Vera Cruz, Mexico.
1904 Apr. 12.	*TISDALL, ALFRED DOUGLAS	Britannia Ironworks, Derby.
1887 Jan. 11.	TIVOLI, JOSEPH WILLIAM DE ..	Tezpur-Balipara Ry., Tezpur, Assam.
1904 Apr. 12.	TOD, JAMES COX, B.Sc. (*Edin*)	1 Queensferry Terrace, Edinburgh.
1880 Mar. 2.	*TODD, AUGUSTUS BYTHESEA ..	Quarry Park, Grampound.
1890 May 20.	TODD, WILLIAM HENRY	Land of Green Ginger, Hull.
1901 Mar. 5.	*TOLHURST, PHILIP WALMESLEY	Northfleet House, Northfleet.
1896 May. 5.	TOMES, GEORGE BRUCE	District Council, Mortlake, S.W.
1890 Apr. 1.	TOMKINS, WILLIAM HENRY ..	Cottesmore, Roydon, Essex.
1903 Apr. 7.	*TOMLINSON, JOHN WILLIAM ..	St. Mary's Hall, Coventry.
1896 Dec. 1.	*TONGE, HAROLD ASHETON ..	5 Brendon House, Great Woodstock Street, W.
1881 May 31.	TONGE, JAMES	Court Chambers, Mawdsley Street, Bolton.
1897 Mar. 2.	*TONGE, JOHN HENRY	21 Lower Bank Road, Fulwood, Preston.
1881 May 31.	TONKIN, WALTER WILLIAM ..	5 Grove Road, Brixton, S.W.
1892 Dec. 6.	TOOKER, HUGH POLLOCK, B.E. (*Queen's*)	c.o. H. S. King & Co., 65 Cornhill, E.C.
1893 Mar. 7.	*TOOTH, STANLEY, M.A. (*Cantab.*)	Clare Grange, Prideaux Road, Eastbourne.
✠ 1885 Dec. 1.	*TOPHAM, FRANCIS DAVID .	King, King & Co., Bombay.
1899 Dec. 5.	*TOPHAM, THOMAS EDWARD ..	Govt. Rys., Durban, Natal.
1873 Dec. 2.	*TOPLIS, FREDERICK	60 Crouch Hill, N.
1878 Feb. 5.	*TORRENS, GERARD PHILIP ..	19 Queensberry Place, S.W.
1890 Dec. 2.	TOUCHON, AUGUSTE	14 Caixa do Correio, Rio de Janeiro.
1894 Dec. 4.	TOWLSON, SAMUEL	District Council, Sevenoaks.
1880 Mar. 2.	*TOWNSEND, CHARLES JOHN HENRY FYLER	Laksam, Assam-Bengal Ry., Tippera, Bengal.
1900 Jan. 9.	TOWNSEND, EDWARD HUME, B.A.I. (*Dubl.*)	Manchester Waterworks, Contractors' Office, Windermere.

Date of Election.	ASSOCIATE MEMBERS.	
1875 Jan. 12.	*Townsend, Francis Edward	The Manse. Keady, co. Armagh.
1885 Jan. 13.	Townsend, Harry	Gasworks, Wakefield.
✠ 1884 Dec. 2.	Townshend, Bernard O'Driscoll	72 Durnford Street, Stonehous Devon.
1904 Apr. 19.	Tozer, William Henry ..	1 Exmouth Villas, Hampton Hill.
1893 Feb. 7.	Travers, Thomas Patrick ..	Gasworks, Cork.
1890 Apr. 1.	Treglown, Charles Hockin	3 Soho Avenue, Handsworth.
1904 Jan. 12.	Tremelling, Hubert	Boro' Engineer's Office, Newport, Mo
1886 Jan. 12.	Trench, Gilbert Kennedy ..	50 Marmora Rd., Honor Oak, S.E
1897 Feb. 2.	Trenchard, Henry Gottreux	Goninan & Co., Wickham, Ne castle, New South Wales.
1893 May 16.	Trery, Eugene Horace ..	Calle Sucre 1915, Belgrano, Buen Aires.
1894 Dec. 4.	Trestrail, Nicholas	Claremont Road, Redruth.
1899 Dec. 5.	Trew, George Harry Male	H.M. Dockyard, Sheerness.
1881 May 31.	Trier, Frank Henry Julius	1 Great George Street, S.W.
✠ 1894 Mar. 6.	Triffitt, John	N.E. Ry., Eng.'s Office, York.
1899 Dec. 5.	*Trimingham, Norman Stewart Paget	
1892 Apr. 5.	*Tristram, Charles Francis	Lamia, Greece.
1898 Apr. 5.	Trounson, John Cardell ..	Municipal Offices, Plymouth.
1901 Dec. 3.	*Trubshaw, Charles Kenneth	Engineer's Office, Midland Ry., Derb
1892 Dec. 6.	*Trye, Charles Brandon .	Eng.'s Office, Midland Ry., Apperl Bridge, Leeds.
1883 Dec. 4.	Tuck, *Rev.* Edmund Henry ..	107 Tyrwhitt Road, S.E.
m 1897 Apr. 6.	*Tucker, Pierce Joseph	Fairlawn, Molescroft, Beverley.
1892 May 3.	Tucker, Robert Boucher ..	39 Hyde Vale, Greenwich, S.E.
1901 Feb. 5.	Tuckey, William Robinson Townsend, B.E. (*Royal*) ..	Municipal Buildings, Tients China.
1892 Dec. 6.	Tuckwell, John Morrison ..	Rhuarden, Kilmalcom, Renfre shire.
t ✠ 1882 Feb. 7.	*Tufnell, Carleton Fowell	Iver, Kenley, Surrey.
1878 May 28.	Tunstall, John	141 Lordship Road, Stoke Ne ington, N.
1894 Dec. 4.	Turley, Arthur Clifford ..	City Surveyor, Canterbury.
1890 Dec. 2.	*Turnbull, Nicholas King ..	Bradford Ironworks, Manchester.
1869 Mar. 2.	Turner, Frank	Bracondale, Ontario, Canada.
1873 May 20.	Turner, Frank de Mierre ..	Oporto, Portugal.
1884 Dec. 2.	*Turner, John Harrison ..	Wiltshire Foundry, Warminster.
1904 Apr. 12.	*Turner, Vincent	City Hall, Charing Cross Ro W.C.
m 1875 Mar. 2.	*Tweedie, William	New Hamburg Ry., Porto Aleg Brazil.
1894 Feb. 6.	Twiddy, James Handfield ..	Box 192, Klerksdorp, Transvaal
m ✠ 1893 Apr. 11.	*Twinberrow, James Denis ..	15 New Bridge Street, Newcastle-o Tyne.
m ✠ 1904 Mar. 1.	*Tyack, Arthur Henry	H.M. Naval Yard Extension, Ho Kong.
1896 May 5.	Tyler, Edward Henry ..	Kola Gold Fields, Mysore, India.
1902 Feb. 4.	*Tyley, Frederick John ..	Engineer's Office, G.W. Ry., Pa dington, W.
1894 Dec. 4.	Tyrrell, James Henry ..	City and Suburban Tramw Johannesburg, Transvaal.
1890 May 6.	Tyzack, David	Bellingham, Northumberland.
1877 Feb. 6.	Uhagon, Recaredo de	Plaza Eliptica, Bilbao.
1895 Dec. 3.	*Umney, Herbert Williams ..	19 Sylvan Road, Upper Norw
1893 Dec. 5.	*Underwood, William Elphinstone	Thos. Cook & Son, Durban, Nat

Date of Election.	ASSOCIATE MEMBERS.	
1904 Apr. 12.	*UNNA, PERCY JOHN HENRY, B.A. (*Cantab.*)	31 H[illegible]e Park Gate, S.W.
1870 Dec. 6.	UNWIN, HERBERT	Dowdeswell Court, Andoversford, Glos.
1902 Dec. 2.	UNWIN, WILFRID PEYTO	Town House, Haslemere.
1893 Dec. 5.	UPTON, PRESCOTT	Box 1026, Johannesburg, Transvaal.
1884 Dec. 2.	*VACHELL, THEODORE	34 Bridge Street, Newport, Mon.
1879 Mar. 4.	*VACHER, HERBERT PERKINS ..	Vulcan Ironworks, Winchester.
1897 Dec. 7.	*VALON, WALTER ARTHUR ..	140 Temple Chambers, E.C.
1875 May 4.	VALON, WILLIAM ANDREW McINTOSH	140 Temple Chambers, E.C.
✠ 1858 Dec. 7.	VARLEY, SAMUEL ALFRED ..	Arrow Works, Jackson Rd., Holloway, N.
1892 Dec. 6.	VASSALLO, ANDREA..	163 Strada Forni, Valetta, Malta.
1902 Jan. 14.	*VAUGHAN, CEDRIC GEORGE, M.A. (*Cantab.*)	Hodbarrow Mines, Millom, Cumberland.
1902 Feb. 4.	*VAWDREY, ROBERT WILLIAM, B.A. (*Cantab.*)	Middleton, Hunter & Duff, 42 Frederick Street, Edinburgh.
1890 Feb. 4.	VEASEY, THOMAS FREDERICK	
1874 Dec. 1.	VEEVERS, HARRISON	The Lakes, Dukinfield.
1894 May 1.	VENN, ERNEST GALE	Mrs. Davy, 20 Raleigh Road, Exeter.
1899 Jan. 10.	*VENTERS, WILLIAM BEATTIE, B.Sc. (*Glas.*)..	15 Allan Park, Stirling.
1878 Apr. 2.	*VENTRIS, ARTHUR	Campion, Arkwright Rd., Hampstead, N.W.
1888 May 1.	*VERDON, ARTHUR LAWRENCE RIDLEY	c.o. Messrs. J. Simpson & Co., 101 Grosvenor Road, S.W.
1893 Feb. 7.	*VEREKER, FREDERICK JAMES WELLINGTON	H.M. Dockyard Extension, Gibraltar.
1895 Mar. 5.	*VERNET, CHARLES CONSTANT	Western Railway, Havana, Cuba.
1889 Jan. 8.	VERSCHOYLE, BERESFORD ..	F.C. Rosario, Avenida de Mayo 748, Buenos Aires.
1902 Dec. 2.	VERSCHOYLE, ROBERT HENRY	Tarrago, Ballisodare, co. Sligo.
1891 Mar. 3.	*VESIAN, JOHN STUART ELLIS DE	20 New Bridge Street, E.C. (Biceps, London.)
1891 Dec. 1.	VIBART, GEORGE	South Mahratta Ry., Bangalore, India.
1891 Apr. 7.	*VICARS, JAMES, M.E. (*Sydney*)	City Surveyor, Adelaide, S. Australia.
1896 Feb. 4.	*VICKERS, JAMES WARRY ..	Finsbury Square Buildings, E.C.
1893 Dec. 5.	*VIGERS, ARTHUR EVAN	25 Victoria St., S.W. (Westminster, 423.)
1896 Dec. 1.	VILLIERS, BERTRAM MONTAGU	Cotlands, St. Albans, Herts.
1897 Mar. 2.	*VINCENT, SAMUEL JOSEPH LEE	Boro' Surveyor, Newbury.
1877 Dec. 4.	*VINT, GEORGE EDWARD.. ..	53 Victoria Street, S.W.
1886 Jan. 12.	*VINTER, WALTER FREDERICK, B.A. (*Cantab.*)	Glenville, Walton-on-Thames.
1894 Jan. 9.	VIQUEIRA, JOSÉ LOPEZ-CORTON, B.A. (*Madrid*)	Plaza de Orense, La Coruña, Spain.
1887 May 3.	VISVESVARAIYA, MOKSHAGUNDAM, B.A. (*Madras*)	10 Queen's Gardens, Poona, India.
1880 Apr. 6.	VIVIAN, WALTER MORRISON ..	Vellore, North Arcot, Madras.
1887 Jan. 11.	*VOGAN, HAROLD SEBASTIAN ..	Ry. Dept., Bridge St., Sydney, N.S.W.
1902 Jan. 14.	VOLLMER, GEORGE FREDERICK, M.Sc. (*Victoria*)	Denver Union Water Co., Denver, Colo., U.S.
1882 Dec. 5.	*VOYSEY, HENRY WESLEY ..	53 Westbere Road, West Hampstead, N.W.

	Date of Election.	Associate Members.	
✠	1887 Dec. 6.	*Wackrill, Alfred Edward	Mrs. Gee, Rope Walk, Nottin ham.
	1888 Feb. 7.	*Waddell, George	P.W.D., Colombo, Ceylon.
	1890 Dec. 2.	Waddell, William	5 Romilly Road, Barry, Cardiff.
	1883 Dec. 4.	*Waddington, Richard	35 King William Street, E (Bank 518.)
	1888 Feb. 7.	*Waddington, Samuel Sugden	7 Derwent Road, Anerley, S.E.
	1893 May 2.	*Wade, Edward Hyde Robert Wybrants	Railway Avenue, Colombo, Ceyl
	1894 May 1.	*Wade, Henry James Seaton	H.M. Dockyard. Gibraltar.
	1894 Dec. 4.	*Wade, James Scargill	Railway Dept., Sydney, N.S.W.
	1889 Dec. 3.	Wade, Leslie Augustus Burton	Water Conservation Branch, Mi Dept., Sydney, N.S.W.
	1900 Mar. 6.	Wade, Rowland, B.A.I. (*Dubl.*)	Downshire Road, Newry, co. Do
	1896 Mar. 3.	Wade, William Reginald	The Mount, Henbury, Macclesfiel
	1898 Dec. 6.	Wadley, Alfred John	P.W.D., Shahpur, Punjab.
	1898 Mar. 1.	Wagstaff, Edward Wynter	Railway, Rangoon, Burma.
	1894 Mar. 6.	Wagstaff, William Henry	57 Salter Gate, Chesterfield.
	1899 Dec. 5.	Waight, Earle Roberts	Engineer's Office, S.E. Ry., Lond Bridge, S.E.
	1898 Dec. 6.	Wainwright, John William	Parliament Mansions, Victo Street, S.W. (Retocar, Lond Westminster 5323.)
	1894 Mar. 6.	*Waite, Edward William Wilkins	Gas & Water Works, Barry, Card
	1882 May 23.	*Wakefield, Henry Tyndall	County Council, Spring Garde [S.]
	1894 Feb. 6.	Wakeford, John Percy	Town Hall, Bilston.
	1888 Apr. 10.	Waldron, Frank William	Harbour Works, Mossel Bay, Ca Colony.
m ✠	1896 May 19.	*Wales, William Garneys	Priestfield, Mowbray Road, Up Norwood, S.E.
	1897 Apr. 6.	Walker, Albert Harry	Boro' Surveyor, Loughborough.
	1888 Dec. 4.	Walker, Alexander	Arauco Co., Coronel, Chili.
	1890 Mar. 4.	Walker, Alexander Thomson	Waterworks, Reading.
	1904 Jan. 12.	*Walker, Archibald Craig, B.Sc. (*Glas.*)	256 Renfrew Street, Glasgow.
	1904 Apr. 12.	Walker, Charles Clement	"Lilleshall," Bishopswood Ro Highgate, N.
	1903 Jan. 13.	Walker, Cyril Turner, B.Sc. (*Edin.*)	Nizam's Ry., Secunderabad, Decc
	1904 Apr. 12.	Walker, George Dutton	Albion Chambers, King Stre Nottingham.
	1884 Dec. 2.	Walker, Herbert	Albion Chambers, King Stre Nottingham.
	1901 Apr. 2.	Walker, Horatio Edgar Dawson	Engineer's Office, G.N.R., Wellington Street, Leeds.
	1900 Dec. 4.	*Walker, Joah Haigh	18 Blenheim Street, Newcastle Tyne.
	1892 Apr. 5.	Walker, Joseph Robert	Caixa 711, Rio de Janeiro.
	1891 Dec. 1.	*Walker, Murray	Box 97, Cape Town, C.C.
	1904 Apr. 12.	Walker, Norman de Courcy	Canadian Pacific Ry., Mont Canada.
	1879 Dec. 2.	Walker, Robert	17 South Mall, Cork.
	1891 Dec. 1.	*Walker, Robert, Jun., B.E. (*Royal*)	17 South Mall, Cork.
	1900 Dec. 4.	*Walker, Robert Williamson	3 Golden Square, Aberdeen.
	1885 Dec. 1.	Walker, Sydney Ferris	Bloomfield Crescent, Bath.
	1889 Dec. 3.	Walker, William	Lansdowne Crescent, Hobart, Tas mania.
	1896 Feb. 4.	Walker, William Douglas	Ry. Construction Dept., Syd N.S.W.

Date of Election.	ASSOCIATE MEMBERS.	
✠ 1895 May 21.	WALKER, WILLIAM GEORGE ..	47 Victoria Street, S.W. (Versuchen, London.)
1900 Jan. 9.	*WALKER, WILLIAM MONTGOMERY, B.E. (*Royal*).. ..	Kilcadden, Killygordon, co. Donegal.
1875 Dec. 7.	*WALKER, ZACCHEUS	Fox Hollies Hall, nr. Birmingham.
1894 Feb. 6.	WALL, BENSON PARSICK ..	Box 1121, Johannesburg, Transvaal.
1880 Dec. 7.	*WALLACE, JOHN HENRY	Cliffdale, Highlands Station, Natal.
1882 May 23.	*WALLACE, LAWRENCE AUBREY	H. S. King & Co., Pall Mall, S.W.
1895 Dec. 3.	WALLACE, WILLIAM CARLILE	Sirveco Engineering Co., 22 Thames Street, New York, U.S.
1904 Jan. 12.	WALLACE, WILLIAM MACGREGOR	De Beers Science School, Kimberley, Cape Colony.
1893 Mar. 7.	*WALLER, ARTHUR HERBERT ..	Boro' Engineer's Office, Durban, Natal.
1895 May 21.	*WALLER, BERTRAM BRAUND ..	16 Dorville Road, Lee, S.E.
1896 Dec. 1.	WALLER, RICHARD FITZARTHUR	Magnet Mine, Waratah, Tasmania.
1894 Dec. 4.	*WALLICH, EDWARD HENRY ..	Seremban, Negri Sembilan, Malay States.
1884 May 27.	WALLINGTON, JAMES	Rua do Ouvidor 139, Rio de Janeiro.
1889 May 21.	WALLIS-JONES, REGINALD JOHN	50 Queen Anne's Gate, S.W.
1879 Feb. 4.	WALLNUTT, RICHARD	9 Norfolk Street, Moome Ponds, Melbourne, Victoria.
1883 Feb. 6.	*WALROND, THEODORE CHARLES TROUBRIDGE	47 Victoria Street, S.W. (Logistics, London. Westminster 12.)
m 1904 Jan. 12.	*WALSH, ARTHUR CLIFFE ..	S. Pearson & Son, New Dock Works, Malta.
1885 Feb. 3.	*WALSH, CHARLES ARROWSMITH	King, Hamilton & Co., Calcutta.
1898 Apr. 5.	WALSH, CHARLES PEREGRINE ..	c.o. H. S. King & Co., Pall Mall, S.W.
1894 Dec. 4.	WALSH, THOMAS LISTER	Cristobal, Kent Road, Harrogate.
1898 Dec. 6.	WALTER, LOUIS HEATHCOTE, M.A. (*Cantab.*)	4 Glendower Place, S.W.
1886 Mar. 2.	*WALTERS, HARRY ERNEST ..	2 Great George Street, S.W.
1902 Dec. 2.	*WARD, ARTHUR WALBURGH .	Guildhall, Northampton.
1892 Dec. 6.	WARD, ARTHUR WILLIAM ..	Shandon, Merton Road, Southsea.
1889 May 7.	*WARD, EDWARD THOMPSON ..	Winnington Street, Northwich.
1891 Dec. 1.	*WARD, FREDERICK DARWENT	38 High Street, Welshpool.
1902 Apr. 8.	WARD, GODFREY	City Surveyor's Office, Birmingham.
1891 Dec. 1.	WARD, JAMES CARPENTER ..	Milford Docks, Milford Haven.
1892 May 24.	WARD, THOMAS	Grey Street, Wellington, N.Z.
1888 Dec. 4.	WARD, THOMAS HENRY	E.I. Ry., Giridih, India.
1885 Dec. 1.	*WARD, THOMAS RAWDON ..	P.W.D., Colombo, Ceylon.
1896 Jan. 14.	*WARD, THOMAS ROBERT JOHN	Irrigation Branch, P.W.D., Punjab.
1891 Dec. 1.	*WARD, THOMAS WILLIAM CHAPMAN, B.A., B.E. (*Sydney*)	Metropolitan Board of Water Supply and Sewerage, 341 Pitt Street, Sydney, N.S.W.
1884 Mar. 4.	*WARD, WILLIAM PETTIT	Hayes Lane, Bromley Common, Kent.
1887 Dec. 6.	*WARDE, CHARLES PARRY ..	P.W.D., Saidpore, Bengal.
1877 Dec. 4.	*WARDLE, JAMES WILLIAM ..	Borough Engineer, Longton.
1887 Dec. 6.	WARE, GEORGE WEBB	Dumri P.O., viâ Giridih, Bengal.
1895 Dec. 3.	WARE, STANLEY DAWSON ..	Pollavaram, Godavery District, Madras.
✠ 1898 Dec. 6.	WARK, WILLIAM	9 Macquarie Place, Sydney, N.S.W.
1888 Dec. 4.	WARNER, WILLIAM	Westwood, Clumber Rd., Nottingham.
1897 Feb. 2.	*WARREN, HAROLD	6 St. Andrew's Street, Cambridge.
1897 Feb. 2.	*WARREN, HENRY BONIFINT GORDON	Old Castle Buildings, Liverpool.
1886 May 4.	*WARREN, JOHN ALEXANDER ..	94 Hope Street, Glasgow.
1885 May 19.	WARREN, WILLIAM	30 St. Swithin's Lane, E.C.
1842 May 3.	WARRINER, HENRY	6 The Grove, Clapham Road, S.W.
1887 Dec. 6.	*WASEY, GEORGE KINDERSLEY	
1888 Jan. 10.	WATANABE, KAICHI, B.Sc. (*Glas.*)	13 Omote-Sanchome, Akasaka, Tokio, Japan.

	Date of Election.	ASSOCIATE MEMBERS.	
	1899 Apr. 11.	WATERHOUSE, LAURENCE MAXWELL	Wilbraham Mansions, Wilbraham Place, Sloane Square, S.W.
	1904 Feb. 2.	*WATERS, WILLIAM	6 South Square, Gray's Inn, W.C.
	1895 Feb. 5.	WATHEN, HENRY ARTHUR DOUGLAS	Waterton, Auchmill, Aberdeenshire.
	1885 Apr. 14.	WATKEYS, GEORGE	Goring Road, Llanelly.
	1897 Mar. 2.	WATKINS, ARTHUR ANDERSON	79 Vanbrugh Park, Blackheath, S.E.
	1875 Dec. 7.	WATKINS, STEPHEN	Prince's Chambers, Wolverhampton.
	1895 Feb. 5.	WATKINS, STEPHEN	Ottoman Railway, Smyrna.
	1891 Dec. 1.	*WATKINS, WILFRID JOHN ARIS	106 Chichele Road, Cricklewood, N.W.
	1901 Apr. 2.	*WATNEY, GERARD NORMAN, B.A. (*Cantab.*)	Valence, Westerham, Kent.
m ✠	1899 Mar. 7.	*WATSON, ARTHUR	L. & Y. Ry., Bolton.
	1898 Apr. 5.	WATSON, CHARLES	Central Station, Newcastle-on-Tyne.
	1891 Feb. 3.	WATSON, CLAUD ROBERT ..	Carment, Wedderburn & Watson, 32 Albany Street, Edinburgh.
	1896 Dec. 1.	*WATSON, FRANK LESLIE ..	2 Balmoral Terrace, Shaw Lane, Leeds.
	1893 Dec. 5.	WATSON, FREDERICK MACKMAN	Selwood, Rotherham.
S t ✠	1894 Dec. 4.	*WATSON, GEORGE	Stonegate, Pool-in-Wharfedale.
	1898 Mar. 1.	WATSON, JAMES FALSHAW ..	15 Shaw Lane, Headingley, Leeds.
	1886 May 18.	*WATSON, JOHN DUNCAN	Tyburn, near Birmingham.
	1902 Dec. 2.	*WATSON, JOHN FRANCIS, B.E. (*Royal*)	Improvement Trust, Bombay.
	1896 Dec. 1.	WATSON, JOHN LOVEGOOD ..	Thos. Cook & Son, Ludgate Circus, E.C.
	1899 Dec. 5.	*WATSON, JOHN WILLIAM ..	Omega Cottage, Charmouth, Dorset.
	1899 Apr. 11.	*WATSON, LEONARD KINGSLEY	41 Oakfield Road, Croydon.
	1895 Apr. 2.	WATSON, THOMAS	Resident Engineer, Coolgardie, Western Australia.
	1901 Apr. 2.	*WATSON, THOMAS AUBREY ..	Bosigran, Whytecliffe Road, Purley.
	1903 Jan. 13.	*WATT, JAMES	3 Golden Square, Aberdeen.
m ✠	1897 Apr. 6.	WATT, THOMAS HARKNESS ..	53 Bothwell Street, Glasgow.
	1878 Feb. 5.	*WATTS, GEORGE KEMPTHORNE	c.o. Watson & Co., 7 Waterloo Place, S.W.
m	1877 May 29.	*WATTS, NICHOLAS	Bank Buildings, Bristol.
	1902 Apr. 8.	WATTS, WILLIAM	Underbank Hall, Deepcar, Penistone.
	1896 Dec. 1.	*WAY, ARTHUR GEORGE	Westminster Engineering Co., Victoria Rd., Willesden Junction, N.W.
	1901 Mar. 5.	WAY, EDWARD JOHN	New Kleinfontein Co., P.O., Benoni, Transvaal.
	1893 Apr. 11.	*WAYNFORTH, *Professor* HARRY MORTON	King's College, Strand, W.C.
	1888 Dec. 4.	WEARING, WILLIAM	9 Bibblesdale Place, Preston.
	1891 Apr. 7.	WEAVER, EDWARD	Saltfleet St. Peter's, Louth, Lincs.
	1882 Dec. 5.	WEAVER, HENRY EDWARD ..	Caixa do Correio 54, Manaos, Amazonas, Brazil.
	1886 Dec. 7.	WEBB, RICHARD GEORGE ..	Richardson & Cruddas, Byculla, Bombay.
	1887 May 3.	*WEBSTER, CHARLES..	32 Ellesmere Road, Chiswick, W.
	1890 Apr. 1.	*WEBSTER, GEORGE JOHNSTON	Drainage Board, Whakatane, Auckland, N.Z.
	1890 Dec. 2.	WEBSTER, JAMES PHILIP.. ..	Boro' Engineer, Marrickville, Sydney, N.S.W.
	1875 Apr. 6.	WEBSTER, JOHN	Exning, Newmarket.
	1903 Apr. 7.	*WEDGWOOD, ARTHUR FELIX ..	7 Sydenham Terrace, Newcastle-on-Tyne.
	1899 Dec. 5.	*WEEKES, MICHAEL GEORGE ..	Derwent Valley Water Board, Bamford, Sheffield.
	1893 Feb. 7.	*WEEKES, ROBERT WILLSHER ..	65 Hayes Road, Bromley, Kent.
	1904 Feb. 2.	*WEEKLEY, CHARLES, B.A. (*Cantab.*)	16 Brook Green, Hammersmith, W.

	Date of Election.	ASSOCIATE MEMBERS.	
	1902 Dec. 2.	Weightman, Thomas Jackson	Engineer's Office, G.N. Ry., King's Cross, N.
	1885 May 19.	Weinschenck, Guilherme Benjamin	Caixa 27, Santos, Brazil.
	1903 Apr. 7.	Weir, James Scott	Borough Engineer's Office, Halifax.
	1894 Dec. 4.	*Weir, William Park	13 Rowallan Gardens, Partick, Glasgow.
	1892 Mar. 1.	*Weiss, Charles Theodore Hermann	T. Bolton & Sons, Oakamoor, Stoke-on-Trent.
	1878 May 7.	*Weiss, Hubert August Otto	Greifswalderstrasse 140, Berlin.
	1880 May 4.	Welch, Ernest Frederick ..	Chargrove Lawn, Cheltenham.
	1886 Jan. 12.	Welch, James William ..	27 Victoria Buildings, Manchester.
	1890 Dec. 2.	*Weldon, Herbert Nicol ..	Norwood Union Chambers, Chamberlain Square, Birmingham.
	1885 Feb. 3.	Weller, Harry Wray	New York Life Building, Place d'Armes, Montreal, Canada.
	1895 Dec. 3.	Wells, George James	138 Marslands Road, Brooklands, Manchester.
	1904 Jan. 12.	Wells, Frederick Beauchamp	Officina Via y Obras, Ferro Carril del Sud, Buenos Aires.
m	1903 Mar. 3.	*Wells, Lionel Fortescue, B.Sc. (*Victoria.*)	Beddgelert, North Wales.
m ✠	1891 Dec. 1.	*Wells, Sidney Herbert ..	Polytechnic Institute, Battersea, S.W.
	1892 Mar. 1.	Welsh, Alexander	7 Morningside Place, Edinburgh.
	1883 Apr. 3.	Welton, William Shakspeare	Elm Road, Wembley, Middlesex.
	1895 Feb. 5.	*Welton, William Smart ..	73 The Chase, Clapham Common, S.W.
	1881 May 3.	Western, Maximilian Richd.	Broadway Chambers, Westminster, S.W.
	1903 Feb. 3.	*Weston, Charles Francis Russell Nugent	32 Beaufort Road, Edgbaston, Birmingham.
	1887 May 24.	Weston, Harry Jacob	24 Portland Street, Southampton.
	1886 Dec. 7.	*Whately, Richard	Bombay, Baroda & C. I. Ry., India.
	1899 Jan. 10.	Wheat, Frederick Sykes ..	18 King's Road, Doncaster.
	1894 Apr. 3.	*Wheatley, Henry Lawrence	Caixa 711, Rio de Janeiro.
	1899 Dec. 5.	Wheeler, Edwin	G. N. Ry., Peterborough.
	1883 Feb. 6.	Wheeler, George Robert Welby	15 Dalebury Road, Upper Tooting, S.W.
	1898 Dec. 5.	*Whetham, Stephen Lloyd ..	c.o. Austen Whetham, Bridport.
	1885 May 19.	Whinfield, John Henry Richard	Brambletye, Cavendish Road, Sutton, Surrey.
	1893 Dec. 5.	Whitaker, George Reginald	Govt. Rys., East London, Cape Colony.
	1891 Dec. 1.	*Whitaker, James	H. Simon, 20 Mount St., Manchester.
	1904 Jan. 12.	*Whitaker, John Stanley, B.Sc. (*Victoria*)	North-Eastern Railway Dock Office, Hull.
	1892 Apr. 5.	*White, Charles Stanley ..	8 Guilford Place, Russell Square, W.C.
	1878 Feb. 5.	*White, Edwin James	Lambeth Brass & Iron Co., Short Street, Lambeth, S.E.
	1887 Mar. 1.	White, George	The Farm, Mexborough.
m ✠	1894 Dec. 4.	*White, Henry Thomas	Handyside & Co., Derby.
	1900 Apr. 3.	White, John Henry	King, King & Co., Bombay.
	1893 Dec. 5.	White, Robert Henry	The Elms, Field Lane, Litherland, Liverpool.
	1894 Feb. 6.	White, Sydney Herbert ..	A. T. Walmisley, 9 Victoria St., S.W.
	1887 Mar. 1.	White, Thomas Charles Hutchinson	28 Cromwell Grove, Hammersmith, W.
	1896 Mar. 3.	White, William Donald Wilson	7 Grosvenor Terrace, Ayr, N.B.
	1901 Dec. 3.	White, William Henry John	Municipal Offices, Cheltenham.
	1897 Dec. 7.	*White, William Herbert ..	10 Suffield Chambers, 79 Davies Street, W.

Date of Election.	ASSOCIATE MEMBERS.	
1899 Apr. 11.	*WHITEFORD, ERIC HAMILTON	Derwent Valley Water Board, Bamford, Sheffield.
1902 Mar. 4.	WHITELAW, ANDREW HEPBURN, B.Sc. (*Glas.*)	45 John Street, Glasgow.
1893 Dec. 5.	*WHITELAW, JOHN	46 Albany Street, Edinburgh.
1893 Dec. 5.	WHITELOW, EDWARD TURNER	70 Deansgate, Manchester.
1893 May 2.	WHITHARD, BROOKE MIDDLEMORE	Sewell & Crowther, 18 Cockspur Street, S.W.
1904 Apr. 12.	*WHITTLE, FREDERIC EDWIN	H.M. Dockyard, Portsmouth.
1880 Mar. 2.	*WHITMORE, LAWRENCE HERBER	Box 163, Bulawayo, Rhodesia.
1900 Dec. 4.	WHITTOW, THOMAS	6 Smith Square, Westminster, S.W.
1893 Mar. 7.	WHITWORTH, THOMPSON	3 York Terrace, Eglinton Road, Plumstead, S.E.
1896 Jan. 14.	WHITWORTH, WALTER STANLEY	Koffyfontein Mines, Orange River Colony.
1892 Dec. 6.	WHYATT, HENRY GILBERT ..	Borough Engineer, Great Grimsby
1896 May 5.	WHYTE, JAMES	New Junction Canal, Stainforth, Doncaster.
1888 Jan. 10.	*WHYTE-BUTLER, ARTHUR HENRY	14 Phœnix Lodge Mansions, Brook Green, W.
1895 Dec. 3.	WICKHAM, FRANCIS EDMUND ..	Ry. Construction Branch, P.W.D. Sydney, N.S.W.
1898 Mar. 1.	*WICKHAM, WILLIAM HENRY ..	Hong Kong Electric Co., Hong Kong.
1893 Jan. 10.	WIGG, WILLIS	150 Fosse Road, Leicester.
1893 Mar. 7.	WIGNALL, JOHN ROBERT	Blackwell & Co., 59 City Road, E.C.
1876 Mar. 7.	WILD, JOSEPH HENRY	Box 247, Johannesburg, Transvaal.
1894 Dec. 4.	WILDER, FRANCIS LANGHAM ..	Sulham, Pangbourne, Reading.
1904 Apr. 12.	WILKINSON, FRANK	Peel House, Shawforth, Rochdale.
1885 Feb. 3.	*WILKINSON, HENRY WALL ..	2 Queen Anne's Gate, Westminster, S.W.
1887 Feb. 1.	WILKINSON, JAMES PICKLES ..	301 Corn Exchange Chambers, Cathedral Street, Manchester.
1890 Apr. 1.	*WILKINSON, WILLIAM FISCHER	Consolidated Goldfields of South Africa, 8 Old Jewry, E.C.
1904 Jan. 12.	WILLANS, THOMAS BOWDEN, M.Sc. (*Victoria*)	10 Crosby Street, Stockport.
1883 Feb. 6.	*WILLCOX, JOSEPH EDWARD ..	63 Temple Row, Birmingham.
1897 Apr. 6.	WILLEY, HENRY ALFRED ..	3 Pennsylvania Park, Exeter. (Sylvan, Exeter. 133.)
1892 Dec. 6.	WILLIAMS, ARTHUR EDWARD	Dagenham Dock, Romford.
1895 Dec. 3.	WILLIAMS, ARTHUR EDWARD, B.A. (*Cantab.*)	H. Pontifex & Sons, Shoe Lane, E.C.
1895 Feb. 5.	*WILLIAMS, ARTHUR JOHN ..	H.M. Naval Yard Extension, Hong Kong.
1895 Dec. 3.	WILLIAMS, CHARLES BEYNON ..	P.W.D., Gujranwala, Punjab.
1881 Apr. 5.	*WILLIAMS, CLAUDE ST. MAUR	Belle Vue, Harrow-on-the-Hill.
1902 Dec. 2.	WILLIAMS, CECIL WRENNE, B.A. (*Cantab.*)	Mersey Docks, Liverpool.
1889 May 7.	WILLIAMS, ERNEST	Bewick, Moreing & Co., Box 955, Johannesburg, Transvaal.
1892 May 24.	WILLIAMS, FRANK LIONEL ..	4 Molesworth Terrace, Stoke, Devonport.
✠ 1897 Dec. 7.	*WILLIAMS, GEORGE BRANSBY ..	5 Kensington Mansions, Earl's Court, S.W.
1881 Feb. 1.	*WILLIAMS, JOHN HENRY ..	48 Halford Rd., Richmond, S.W.
1900 Feb. 6.	*WILLIAMS, JOHN HUW	State Ry. Dept., Perak, S.S.
1887 Dec. 6.	WILLIAMS, ROBERT	30 Clement's Lane, E.C. (Egophary. London. 1249.)
1904 Jan. 12.	WILLIAMS, STEPHEN GEORGE	Municipal Offices, Singapore, S.S.
1897 Feb. 2.	*WILLIAMS, STEPHEN MAYNARD JENOUR	Madras Ry., Rayapuram, Madras.
1893 Dec. 5.	WILLIAMS, WILLIAM HUMPHREYS	Engineer's Office, Maritime Chambers, Docks, Southampton.

Date of Election.		ASSOCIATE MEMBERS.	
	1896 Apr. 14.	WILLIAMS, WILLIAM RICHARD, F.C.H.	Irrigation Dept. Alexandria, Egypt.
m	1871 Dec. 5.	*WILLIAMS, WILLIAM WALTON	Messrs. Lysaght, Gibraltar.
	1903 Mar. 3.	*WILLIAMS - ELLIS, RUPERT GREAVES, B.A. (*Cantab.*)	FerryWorks,Thames Ditton, Surrey.
	1904 Mar. 1.	WILLIAMSON, ALEXANDER, B.Sc. (*Glas.*)	Craigbarnet, Greenock, N.B.
	1896 Feb. 4.	*WILLIAMSON, ALFRED ARTHUR	Works Dept.,H.M. Dockyard,Devonport.
	1892 Apr. 5.	*WILLIAMSON, ANDREW	Cannanore, N. Malabar, India.
	1890 Jan. 14.	*WILLIAMSON, ARTHUR	City Engineer's Dept., Cape Town, C.C.
	1892 Mar. 1.	WILLIAMSON, RICHARD	South Lodge, Cockermouth.
	1886 May 18.	*WILLINK, WILHEM	35 Copthall Avenue, E.C.
	1901 Apr. 2.	WILLIS, EDWARD	Public Offices, Dyne Road, Kilburn, N.W.
	1902 Apr. 8.	*WILLIS, JOHN BURDETT	27 Pulteney Rd., South Woodford.
	1878 May 28.	*WILLIS, ROBERT HENRY	29 Grafton St., Fitzroy Square, W.
	1894 Mar. 6.	WILLIS-VOLLAIRE, GEORGE	London Sanitary Protection Association, 13 Charles St.,St.James', S.W.
	1895 Dec. 3.	*WILLMOTT, HERBERT MORTON, F.C.H.	c.o. Grindlay & Co., Parliament Street, S.W.
	1898 Dec. 6.	*WILLOUGHBY, PERCIVAL ROBERT AUGUSTUS	Council Offices, Pontypridd, Glamorgan.
	1896 Mar. 3.	*WILLS, BERNARD RUSSELL, B.A. (*Cantab.*)	Brennan Torpedo Factory, Chatham.
	1899 Feb. 7.	WILSHERE, FRANK	24 Queen Anne's Gate, S.W.
	1898 Dec. 6.	WILSON, ALAN	Wilson and Neubronner, Penang, S.S.
	1904 Jan. 12.	*WILSON, ALBERT, B.Sc. (*Lond.*)	Sanitary Commission, Gibraltar.
	1897 Apr. 6.	WILSON, ALEXANDER COWAN	L. P. Nott, 17 Priory Street, Birkenhead.
	1869 Dec. 7.	WILSON, ALEXANDER FAIRLIE	Burnbrae, Balfron, N.B.
	1902 Dec. 2.	WILSON, ANDREW	14 Queen Street, Edinburgh.
	1879 Feb. 4.	*WILSON, ARTHUR HENRY	5 Clifton Hill, Clifton, Bristol.
	1894 Dec. 4.	WILSON, DANIEL ELLIS	Ras-el-Haleeg, Gharbieh, Lower Egypt.
	1903 Feb. 3.	WILSON, DAVID, B.E. (*Royal*)	Engineer-in-Chief's Office, Govt. Rys., Maritzburg, Natal.
	1904 Jan. 12.	WILSON, EDWARD ARTHUR	Half Acres, Bishop's Stortford.
	1895 Mar. 5.	*WILSON, ERNEST MOORE	Reduction of Gradients, Eastern System, Cape Colony.
	1904 Apr. 12.	WILSON, FREDERICK	40 Leopold Rd., St. Andrews, Bristol.
t ✠	1898 Mar. 1.	WILSON, GEORGE, D.Sc. (*Victoria.*)	151 Hamilton Road, Longsight, Manchester.
	1879 Mar. 4.	WILSON, JAMES, *Pasha*	19 Lymington Road, West Hampstead, N W.
	1902 Apr. 8.	WILSON, JOHN FAIRWEATHER	Dockyard Extension, Simon's Town, Cape Colony.
	1904 Jan. 12.	WILSON, JOHN FRANCE	Gloucester Place, Ashton-under-Lyne.
	1903 Feb. 3.	*WILSON, JOHN SIGISMUND	19 Lymington Road, West Hampstead, N.W.
	1898 Jan. 11.	WILSON, JOSEPH BOWMAN	Court House, Cockermouth.
	1888 Jan. 10.	*WILSON, MAURICE	Engineering School, Crystal Palace, S.E.
	1895 Dec. 3.	*WILSON, NORMAN FORSTER	5 Bankfield, Kendal.
	1893 Dec. 5.	*WILSON, NORMAN McLEOD RAMSAY	Dearne Valley Ry., Barnbrough, Doncaster.
	1898 Dec. 6.	WILSON, ROBERT MACDONALD	E.B.S.Ry.,Krishnagar,Nadia,Bengal.
	1886 Dec. 7.	WILSON, THOMAS BRIGHT	Epworth Lodge, Ashcroft, Cirencester.
	1876 Apr. 4.	WILSON, THOMAS PERCEVAL	Easton, Anderson & Goolden, Broad Sanctuary Chambers, S.W.
	1896 May 5.	WILSON, WILLIAM	Board of Works, Melbourne, Victoria.

	Date of Election.	ASSOCIATE MEMBERS.	
m	1875 Mar. 2.	*WILTON, FRANCIS	Knockeevan, Priest Hill, Caversham Reading.
m	1902 Dec. 2.	*WIMPERIS, HARRY EGERTON, B.A. (*Cantab.*)	20 Granard Road, Wandsworth Common, S.W.
	1871 Dec. 5.	WINCKLER, GEORGE WALTER ..	Winnipeg, Canada.
	1899 Apr. 11.	*WINDER, OLIVER	Ely House, Newton Heath, Manchester.
	1891 Apr. 7.	WINDER, THOMAS	Norfolk Estates Office, Sheffield.
	1873 May 20.	*WINDHAM, FRANCIS	c.o. J. Walker, Station Road, Chingford.
	1896 Dec. 1.	WINDLE, JAMES FITZGERALD	County Surveyor's Office, Limerick.
	1886 Feb. 2.	*WINDOW, EDMUND RICHARD ..	2 Church Street, Liverpool.
	1903 Feb. 3.	*WINDSOR, DOUGLAS HALLIBURTON	Superintending Engineer's Office, H.M. Dockyard, Portsmouth.
	1902 Jan. 14.	*WINGATE-SAUL, ARTHUR WINGATE	Yates & Thom, Canal Foundry, Blackburn.
	1898 Dec. 6.	WINN, THOMAS JOHN	44 Hilldrop Crescent, Camden Rd., N.
	1879 Feb. 4.	WINSHIP, GEORGE	Borough Surveyor, Abingdon.
✠	1897 Mar. 2.	WINSLOW, GILBERT, B.A. (*Cantab.*)	Macquece Manica, Portuguese East Africa.
	1887 Feb. 1.	WINSTANLEY, WILLIAM	Gasworks, Newcastle-under-Lyne.
	1895 May 21.	WINTER, GEORGE BLISS	S. Indian Ry., Trichinopoly, India.
	1894 Dec. 4.	WINTER, OLIVER ERNEST ..	Borough Engineer, Town Hall, Haverstock Hill, N.W.
	1902 Jan. 14.	*WISE, JULIAN STANTON	Dalzien, West Heath Road, Abbey Wood.
	1892 Feb. 2.	*WISSENDEN, REGINALD	Contractor's Office, Lofthouse, Pateley Bridge, Leeds.
	1885 Jan. 13.	WISWALL, FRANCIS	Stanley Villas, Runcorn.
	1903 Mar. 3.	*WISWALL, WALTER HARTLEY	Ship Canal, Runcorn, Cheshire.
	1875 Dec. 7.	WITTS, GEORGE BACKHOUSE ..	Hill House, Leckhampton, Cheltenham.
	1895 Jan. 8.	WITTS, JOHN WILLIAM	City Engineer's Office, Leeds.
	1895 Jan. 8.	*WOLFENDEN, BENJAMIN JAMES	Boro' Engineer, Bootle.
m ✠	1899 Mar. 7.	*WOLFF, CHARLES ERNEST, B.Sc. (*Victoria*)	Turf Club, Cairo, Egypt.
	1892 Apr. 5.	*WOLLHEIM, ALBERT	Giselastrasse 6, Vienna.
m	1899 Dec. 5.	*WOLSELEY - LEWIS, FRANK THOMAS	Eirianva, North Malvern.
	1888 Jan. 10.	WOLSTENHOLME, JEREMIAH ..	Birley Street, Blackpool.
	1904 Jan. 12.	*WONTNER-SMITH, HOWARD ..	9 Blenheim Road, Manningham, Bradford.
	1894 Dec. 4.	*WOOD, FRANCIS	Borough Surveyor, Fulham, S.W.
	1897 Jan. 12.	WOOD, FREDERICK JAMES ..	County Surveyor, Lewes.
	1895 Dec. 3.	WOOD, JAMES HERBERT ..	Pacific Co., Pacasmayo, Peru.
	1897 Feb. 2.	WOOD, JOHN EGERTON	Mÿnbouw Maatschappij "Loemar," *viâ* Singkawang, Dutch Borneo.
	1887 Dec. 6.	*WOOD, WALTER GUNNELL ..	P.W.D., Faizabad, India.
	1884 Dec. 2.	*WOOD, WILLIAM	31 Studley Road, Clapham Road, S.W.
	1893 Mar. 7.	WOODBURN, ALEXANDER, B.Sc. (*Glas.*)	Southcote, Prestwick, N.B.
	1896 Apr. 14.	*WOOD-HILL, ARTHUR	37 Rosary Gardens, S. Kensington, S.W.
	1881 May 31.	*WOODS, JOHN	Box 784, Cape Town, C.C.
	1887 Dec. 6.	WOODS, VINCENT SYDNEY ..	Maryfield, Retford.
	1889 May 21.	*WOODSIDE, JOHN	Carnsampson, Ballycastle, Co. Antrim.
	1893 Jan. 10.	*WOODWARD, ERNEST ARTHUR BORAMAN	Waterworks Engineer, Wolverhampton.
	1896 Dec. 1.	WOODWARD, HARRY PAGE ..	129 Beaufort Street, Chelsea, S.W.
	1894 Feb. 6.	*WOODWARD, HENRY RICHARD KEMP	G.W. Ry., Low Level Station, Wolverhampton.
	1891 Dec. 1.	*WOODWARD, JOHN HAROLD ..	8 Queen Anne's Gate, S.W.

	Date of Election.	ASSOCIATE MEMBERS.	
	1893 Feb. 7.	*Woolcock, Joseph Henry ..	Rickerby House, St. Bees.
	1897 Jan. 12.	*Woolmer, Herbert Charles Palairet	
✠	1899 Dec. 5.	*Woore, John Maurice Simeon, B.E. (*Sydney*)	P.O., Claremont, Western Australia.
	1897 Apr. 6.	Wootton, Henry	F. C. Oeste, Buenos Aires.
	1882 Feb. 7.	*Worger, Douglas Fitzgerald	WaterCo.,SouthwarkBridgeRd.,S.E.
	1898 Dec. 6.	*Workman, Frederic Dickinson	Croaghaun, Kingsfield Road, New Bushey.
	1892 Jan. 12.	Wormald, John	14 Victoria Street, S.W.
	1896 Apr. 14.	Worrall, Frank	Council Offices, Long Eaton, Nottingham.
	1896 Apr. 14.	Worsöe, Adam Frederic Trampe	Drammen Foundry, Drammen, Norway.
	1889 Dec. 3.	Worth, Reginald Turner ..	The Limes, Middlewich, Cheshire.
	1893 Dec. 5.	*Worth, Richard George Hansford	42 George Street, Plymouth.
	1894 Dec. 4.	*Worthington, Arthur	Ash Lea, Edgeley, Stockport.
S t ✠	1885 May 19.	Worthington, Edgar, B.Sc. (*Victoria*)	25 Ladbroke Square, W.
	1904 Jan. 12.	*Wray, Peter Remus ..	8 Roxburgh Place, Heaton, Newcastle-on-Tyne.
	1895 Jan. 8.	*Wrench, Francis Houlton ..	Independent Buildings, Fargate, Sheffield.
	1887 May 3.	Wrey, Philip Bourchier Sherard	Mashonaland Agency, Bulawayo, Rhodesia.
	1894 Jan. 9.	Wright, Arthur	26 Park Crescent, Brighton.
	1904 Apr. 12.	*Wright, Christopher Gordon	Naval Works Loan Department, Hong Kong.
	1902 Apr 8.	*Wright, Frank	H.M. Dockyard, Malta.
	1884 Feb. 5.	*Wright, Frederick Adlard ..	Burton Cottage, Boston, Lincs.
	1886 Dec. 7.	*Wright, Harold	East Indian Ry., Asansol, India.
	1890 Feb. 4.	Wright, John Robert Mosse	Suburban Waterworks, Albion Springs, Rondebosch, Cape Colony.
	1901 Apr. 23.	Wright, Richard Ernest ..	Railway Dept., Cape Town, C.C.
	1892 Mar. 1.	*Wright, Thomas	Premier Gas Engine Co., Sandiacre, Nottingham.
	1892 Jan. 12.	Wrixon, Henry	G.P.O., Perth, W. Australia.
	1890 May 6.	*Wyatt, Henry Herbert ..	Buckingham House, Tunbridge Wells.
t ✠	1883 May 29.	*Wyatt, James William, F.C.H.	Bryn Gwynan, Beddgelert, North Wales.
	1901 Dec. 3.	*Wyatt-Smith, Alan	76 Lansdowne Rd., Notting Hill, W.
	1878 May 7.	Wybrow, George Digby ..	Sylvabelle, Lansdown Road, Bournemouth.
	1894 Dec. 4.	Wylde, Thomas	c.o. F. A. Robinson & Co., 54 Old Broad Street, E.C.
	1897 Feb. 2.	Wyllie, James Brown	219 St. Vincent Street, Glasgow.
	1866 Feb. 6.	Wyndham, Henry	9 Victoria Street, S.W.
	1861 Feb. 5.	Wynne, Albert Augustus ..	Tigroney, Ovoca, co. Wicklow.
	1899 Dec. 5.	*Wynne, Arthur Algernon Warren, M.A. (*Cantab.*) ..	C. A. Parsons & Co., 66 Victoria Street, S.W.
	1871 Feb. 7.	*Wynne, Francis George ..	Lightwater, Bagshot.
	1892 Mar. 1.	*Wynne, Henry Edward ..	Engineer's Office, Enniskillen, Ireland.
	1896 Dec. 1.	Wynne, Henry John	Government Rys., Wellington, N.Z.
	1891 Dec. 1.	Wynne, Thomas Trafford ..	Tutbury, Staffs.
	1894 Dec. 4.	Wynne-Roberts, Robert Owen	City Engineer, Cape Town, C.C.
	1890 Dec. 2	Wyse, Robert Anderson ..	Abbotsford House, Nahoon, East London, S. Africa.

	Date of Election.	ASSOCIATE MEMBERS.	
	1895 Dec. 3.	*XAVIER, ISIDORE MICHAEL ..	Water Dept., Victoria, Hong Kong.
	1902 Feb. 4.	YAMAGUCHI, JUNNOSUKE ..	Sanyo Railway, Kobe, Japan.
	1887 Feb. 1.	*YATES, FRED SPENCER	Town Hall, Waterloo, Liverpool.
	1895 Mar. 5.	YERBURY, FREDERICK AUGUSTUS	Oaklea, Grove Park, Lenzie, N.B.
	1899 Dec. 5.	YOCKNEY, ALGERNON LANGSTON	53 Victoria Street, S.W. (Yockney, London. P.O. Telephone—Victoria 53.)
	1891 Dec. 1.	YORK, FRANCIS COLIN	Pacific Ry., Junin, Buenos Aires.
	1895 Mar. 5.	YORK, HENRY	District Council, New Barnet.
	1900 Feb. 6.	YOSHIMURA, CHOSAKU	Kenchikukwa, Sascho Chinjufu Nagasaki Ken, Japan.
m ✠	1895 Apr. 2.	*YOUNG, ALFRED ERNEST	Govt. Survey, Perak, S.S.
	1892 Jan. 12.	YOUNG, EDWARD HERBERT ..	20 Exchange Street East, Liverpool
✠	1891 May 12.	*YOUNG, EVELYN HENRY	Agent's Office, B. B. & C. I. Ry. Bombay.
	1893 Dec. 5.	*YOUNG, JAMES	Caerleon, Bearsden, Dumbartonshire.
	1882 Feb. 7.	*YOUNG, JULES DENT	Waterworks Office, Bath.
	1889 Mar. 5.	YOUNG, ROBERT AUSTEN	Westport, N.Z.
	1892 Apr. 5.	YOUNG, WILLIAM CHRISTOPHER	Mozufferpore, Tirhoot, Bengal.
	1882 Dec. 5.	YOUNGER, THOMAS BROWN ..	98 Great Tower Street, E.C.
	1871 Apr. 4.	YUILL, WILLIAM	Gordondale House, King's Gate Aberdeen.
	1899 Dec. 5.	*ZELLER, CARLOS VAN	48 Rua do Ferregial de Baixo, Lisbon
✠	1901 Dec. 3.	ZIMMER, GEORGE FREDERICK ..	82 Mark Lane, E.C.

Total number of Associate Members .. .. 4.113.

ASSOCIATES.

[Assoc. Inst. C.E.]

N.B. *Those elected prior to the* 2nd *of December*, 1878, *are entitled to the privileges of Corporate Membership, but not those subsequently elected.*

Date of Election.	ASSOCIATES.	
1861 May 28.	ABEL, CHARLES DENTON	28 Southampton Buildings, Chancery Lane, W.C. (Patentable, London. Holborn 109.)
1859 Dec. 6.	AIRD, *Sir* JOHN, *Bart.*, M.P. ..	37 Great George Street, S.W. (Looo. London. Westminster 61.)
1886 Dec. 7.	AIRD, JOHN, Jun.	
1883 Dec. 4.	ALDRICH, ARTHUR STANHOPE ..	Bunnythorpe, Palmerston North, N.Z.
1877 Apr. 10.	ANNETT, RICHARD CHARLES FRANCIS	4 Buckingham Avenue, Sefton Park, Liverpool.
1866 Dec. 4.	ARDAGH, *Sir* JOHN CHARLES, *Maj.-Gen.* R.E., K.C.I.E., K.C.M.G., C.B.	Athenæum Club, Pall Mall, S.W.
1898 Apr. 5.	ARMITAGE, ROBERT, B.A. (*Cantab.*)	Farnley Lodge, Leeds.
1904 Apr. 12.	ARMSTRONG, *Lord*, M.A. (*Cantab.*), D.C.L. (*Durham*)	93 Eaton Square, S.W.
1886 May 4.	ARMYTAGE, *Sir* GEORGE JOHN, *Bart.*	Kirklees, Brighouse.
1901 Dec. 3.	*ARMYTAGE, JOHN HAWKSWORTH	1 Whitehall, S.W.
✠ 1877 Dec. 4.	BACHE, ALFRED, B.A. (*Lond.*)	3 St. Mary's Place, Penzance.
1889 Feb. 5.	BACK, FREDERICK	Chillagoe, North Queensland.
1869 Apr. 6.	BADGLEY, WILLIAM FRANCIS, *Colonel Bombay Staff Corps*	Exmouth, Devon.
1896 Dec. 1.	BAGGALLAY, CLAUDE, K.C., LL.M. (*Cantab.*)	20 Elvaston Place, Kensington, S.W.
1881 May 3.	BAIRD, ANDREW WILSON, *Colonel* R.E. *ret.*, C.S.I., F.R.S.	Palmerscross, Elgin, N.B.
1902 Jan. 14.	BAKER, FREDERICK NOLAN, *Lieut.* R.A.	Charles Cammell & Co., Coventry.
1865 Feb. 7.	BARCLAY, CHARLES	The Manor House, Bayford. Hertford.
1891 May 5.	BARLING, JOSEPH	Under Secy., P.W.D., Sydney, N.S.W.
1885 Dec. 1.	BASTOS, JOSÉ JOAQUIM DE CARVALHO	Rio de Janeiro.
1882 Apr. 4.	BATE, CHARLES M'GUIRE, *Lieut.-Colonel* R.E.	C.R.E., Headquarter Office, Belfast.
1868 Feb. 4.	BEHR, FRITZ BERNARD	5 Queen Anne's Gate, Westminster, S.W.
1900 Dec. 4.	BEHRENS, GUSTAV	36 Princess Street, Manchester.
✠ 1901 Mar. 5.	BEILBY, GEORGE THOMAS ..	8 University Gardens, Glasgow.
1902 Dec. 2.	BELL, CHARLES THORNHILL, *Major* R.A.	Supt., Gun Carriage Factory, Bombay.
1878 May 28.	BEVAN, Rev. JAMES OLIVER, M.A. (*Cantab.*)	Chillenden Rectory, Dover.

	Date of Election.	ASSOCIATES.	
	1885 May 19.	BIRT, *Sir* WILLIAM	Devonshire House, Shortland Kent.
	1886 Dec. 7.	BIXBY, WILLIAM HERBERT *Major U.S. Engs.*	c.o. Adjutant-General, U.S. Arm Washington, U.S. [S.V
	1891 Jan. 13.	BLISSETT, THOMAS	c/o Grindlay & Co., Parliament S
t ✠	1896 Apr. 14.	BLOUNT, BERTRAM	76 York Street, Westminster, S.W
	1901 Apr. 2.	BLOXAM, ARTHUR GEORGE ..	Birkbeck Bank Chambers, South ampton Buildings, W.C.
T t ✠	1856 Dec. 2.	BOULTON, SAMUEL BAGSTER ..	64 Cannon Street, E.C. (Burbou London. Bank 547.)
	1892 Dec. 6.	BOUSFIELD, JOHN EBENEZER ..	4 South Street, Finsbury, E.C. (In vention, London. Central 4492.
	1881 Feb. 1.	*BOUSFIELD, WILLIAM ROBERT, K.C., M.P.	2 Crown Office Row, Temple, E.C.
✠	1841 June 15. 1867 Nov. 26.	BOUSTEAD, JOHN	34 Craven Street, Strand, W.C.
	1887 Apr. 5.	BOWMAN, FREDERIC HUNGERFORD, D.Sc. (*Richmond, U.S.*) F.R.S.E.	Spinningfield, Deansgate, Manchester.
✠	1865 Feb 7.	BRAND, JAMES	172 Buchanan Street, Glasgow.
	1866 Dec. 4.	BRASSEY, *Lord*, K.C.B., D.C.L. (*Oxon.*)	4 Great George Street, S.W. (Westminster 2.)
	1904 Apr. 12.	BRASSEY, *Hon.* THOMAS ALLNUTT, M.A. (*Oxon*) ..	23 Park Lane, W.
	1869 Dec. 7.	BRISTOW, EBENEZER JOHN ..	1 Copthall Buildings, E.C.
	1864 Feb. 2.	BROWNING, ARTHUR GIRAUD ..	16 Victoria St., S.W. (Friday, London
	1852 Dec. 7.	BRYDGES, CHARLES JOHN ..	Hudson Bay Co., Winnipeg, Canad
	1895 Dec. 3.	BURT, GEORGE	19 Grosvenor Road, S.W.
	1886 Apr. 6.	BURT, *Sir* JOHN MOWLEM ..	19 Grosvenor Road, S.W.
	1872 Feb. 6.	BUTLER, JAMES WILLIAM ..	Blyth House, Humber Rd., Black heath, S.E.
m ✠	1899 Dec. 5.	BUTTERS, CHARLES	220 Crocker Building, San Fran cisco, Calif., U.S.
	1876 Dec. 5.	CALL, CHARLES FREDERIC, *Lt.-Colonel* R.E. *ret.*	Valescure, St. Raphael (Var) France.
	1866 Dec. 4.	CAPPEL, *Sir* ALBERT JAMES LEPPOC, K.C.I.E.	27 Kensington Court Gardens, S.W
	1885 Jan. 13.	CARD, HENRY	Lewes. [(2608.
	1869 Apr. 6.	CARPMAEL, ARTHUR	24 Southampton Buildings, W.C
	1879 May 6.	CARPMAEL, EDWARD, B.A. (*Cantab.*)	The Ivies, St. Julian's Farm Road Norwood, S.E.
	1867 May 21.	CASTLE, EDWARD JAMES, K.C.	8 King's Bench Walk, Temple, E.C
	1904 Jan. 12.	CASTLE, SYDNEY CHARLES COURTENAY	40 Chancery Lane, London, W.C.
	1865 Feb. 7.	CERERO, RAFAEL, *General Royal Spanish Engineers* ..	Ingenieros del Ejercito, Madrid.
	1899 Dec. 5.	CHATWOOD, SAMUEL	High Lawn, Worsley, Manchester.
	1879 Mar. 4.	CLARK, MATEO	97 Cromwell Road, S.W.
	1897 Mar. 2.	*CLARKE, EDWARD RUSSELL, B.A. (*Cantab.*)	11 King's Bench Walk, Temple, E.C.
	1872 Feb. 6.	CLEGHORN, JOHN	3 Spring Gardens, S.W.
	1868 Apr. 7.	CLUTTON, ROBERT GEORGE ..	9 Whitehall Place, S.W.
	1867 Feb. 5.	COLBRON, JOSEPH PARKIN ..	38 Osborne Villas, Hove, Brighton.
	1899 Feb. 7.	COOKE, WILLIAM GEORGE, ..	35 Walbrook, E.C.
	1883 Feb. 6.	COOMBS, WILLIAM HERON, *Commander* R.N.	Port of Spain, Trinidad.
	1885 May 5.	COPUS, GEORGE	Rotorua, Westwood Road, Southampton
	1898 Dec. 6.	CORDUE, WILLIAM GEORGE RANGER, *Major* R.E.	Calcutta Gate, Fort William, Calcutta.

	Date of Election.	ASSOCIATES.	
	1839 Apr. 30. 1859 Dec. 6.	COTTAM, EDWARD	78 Shakespeare Road, Drayton Court, Hanwell, W.
	1885 Dec. 1.	COX, EDMUND PENLEY	Pernambuco, Brazil.
	1874 May 12.	CRAMPTON, THOMAS HILLAS, B.A. (*Cantab.*)	c/o J. Fort, 45 Holland Road, Kensington, W.
	1879 Apr. 1.	CRESSWELL, JOHN	8 Ash Grove, Wrexham Road, Chester.
	1897 Dec. 7.	CRIPPS, CHARLES ALFRED, K.C.	1 Essex Court, Temple, E.C.
	1890 Jan. 14.	CUBILLO, LEANDRO, *Lt.-Col. Royal Spanish Artillery*	Trubia, Spain.
✠	1880 Jan. 13.	CUNINGHAM, WILLIAM MARTIN	Goff's Oak, Cheshunt, Herts.
T t ✠	1882 Dec. 5.	CUNNINGHAM, ALLAN JOSEPH CHAMPNEYS, *Lt.-Col.* R.E. *ret.*	20 Essex Villas, Kensington, W.
	1882 May 2.	CUTBILL, WALTER JOHN CHARLES	37 Old Jewry, E.C.
	1891 Jan. 13.	DALLAS, JAMES, *Major* R.E. ..	Dean Bank House, Edinburgh.
	1874 Dec. 1.	DAVIS, ALFRED	26 Victoria Street, S.W. (Sivad, London.)
F ✠	1883 Dec. 4.	DAWKINS, W. BOYD, M.A., D.Sc. (*Oxon.*), F.R.S.	Fallowfield House, Fallowfield, Manchester.
t ✠	1867 Dec. 3.	DELANO, WILLIAM HENRY ..	13 Barkston Gardens, Earl's Court, S.W.
	1877 Dec. 4.	DE RANCE, CHARLES EUGENE ..	32 Carshalton Road, Blackpool.
	1874 Apr. 14.	DERWENT, *Lord*	Hackness Hall, Scarborough.
	1891 Dec. 1.	DONKIN, JOHN BLOYD	Union Club, Sydney, N.S.W.
	1875 Apr. 6.	DOWDEN, THOMAS FREEMAN, *Colonel* R.E. *ret.*	c.o. Cox & Co., Charing Cross, S.W.
	1894 Dec. 4.	DUPRAT, AUGUSTO	Southern Brazilian Ry., Rio Grande do Sul, Brazil.
	1869 Dec. 7.	DURNING-LAWRENCE, *Sir* EDWIN, *Bart.*, B.A., LL.B. (*Lond.*), M.P.	13 Carlton House Terrace, S.W.
	1866 Jan. 9.	EDGCOME, WILLIAM HENRY, *Maj.-General* R.E. *ret.* ..	Cooper's Hill Lodge, Englefield Green, Staines.
	1876 Dec. 5.	ELLIS, BASIL PYM	59 Belvedere Road, Lambeth, S.E.
	1904 Apr. 12.	ELLIS, CHARLES EDWARD ..	Rampton Manor, Lincoln.
	1857 Feb. 3	EPSTEIN, LÉON	
	1872 Dec. 3.	EVANS, *Sir* FRANCIS HENRY, *Bart.*, K.C.M.G., M.P. ..	Tubbendens, Orpington, Kent.
✠	1859 Dec. 6.	EVANS, *Sir* JOHN, K.C.B., D.C.L. (*Oxon.*), D.Sc. (*Cantab.*), F.R.S.	Nash Mills, Hemel Hempstead.
	1866 Jan. 9.	FENTON, *Sir* MYLES	Redstone Hall, Redhill, Surrey.
	1877 Feb. 6.	FENWICK, GEORGE TOWNSEND	Forres Park, Trinidad.
	1844 Apr. 2.	FERRIÈRES, *Baron* DU BOIS DE	Bayshill House, Cheltenham.
	1864 May 1.	FIELD, SIDNEY	Ashfield Lodge, near Bury St. Edmunds.
	1852 May 4.	FORREST, JAMES (*Honorary Secretary.*)	The Institution of Civil Engineers, Great George Street, S.W. (Institution, London. Westminster 51.)
	1903 Mar. 3.	FREDERICK, GEORGE CHARLES, *Commander R.N.*	United Service Club, Pall Mall. S.W.
	1896 Dec. 1.	FREEMAN, GEORGE MALLOWS, B.A. (*Oxon.*), K.C.	33 Phillimore Gardens, W.
	1871 Feb. 7.	FREEMAN, WILLIAM GEORGE	c.o. Freeman, Sons & Co., Penryn, Cornwall.
	1895 Dec. 3.	FREEMAN, WILLIAM ROBERT	29 Cambridge Square, Hyde Park, W.
	1875 Jan. 12.	FRERE, RICHARD TUDOR, *Lt.-Colonel* R.E. *ret.*	6 Magdalen Road, St. Leonard's-on-Sea.
	1900 Feb. 6.	FUJII, TERUGORO	Imperial Japanese Navy, 8 Nottingham Place, W.

	Date of Election.	ASSOCIATES.	
	1889 Feb. 5.	GARNETT, WILLIAM TERRELL	Undercliffe House, Bradford.
	1896 Jan. 14.	GIBB, *Sir* GEORGE STEGMANN	General Manager, N.E. Ry., Yor
	1895 Dec. 3.	GIBBON, JAMES AUBREY, *Major* R.E.	Frideswide, Farnborough, Hants.
	1876 Dec. 5.	GIBBS, WILLIAM HENRY ..	2A New Broadway, Ealing, W.
	1888 Jan. 9.	GODFREY, GEORGE BROWN ..	West Gables, Cranleigh, Surrey.
	1902 Jan. 14.	GORDON, JOSEPH GORDON ..	Queen Anne's Mansions, S.W.
	1898 Dec. 6.	GRINLINTON, FREDERICK HENRY, C.M.G.	Surveyor-General, Ceylon.
	1872 Apr. 9.	GRINLINTON, *Sir* JOHN JOSEPH	Rose Hill, Middle Wallop, Stoc bridge, Hants.
	1872 May 7.	GÜMPEL, CHARLES GODFREY ..	3 Elm Road, Beckenham, S.E.
	1874 Dec. 1.	GUNN, WILLIAM CECIL	G. Bailey Toms & Co., 20 Lauren Pountney Lane, E.C.
	1878 Mar. 5.	HAMMOND, GEORGE CRISPIN, *Commander* R.N...	5 Beacon Terrace, Falmouth.
	1871 Dec. 5.	HARDING, JOSEPH RAKE	Local Board of Health, Epsom.
	1887 Dec. 6.	HARRISON, *Sir* RICHARD, *General* R.E., G.C.B., C.M.G. ..	Farringdon House, Honiton Cly Exeter.
	1875 Apr. 6.	HART, CHARLES FREDERICK ..	Devizes, Wilts.
	1858 Apr. 13.	HAWKINS, WILLIAM BAILEY ..	39 Lombard Street, E.C. (Bailey Hawkins, London.)
	1872 Mar. 5.	HAYDON, WILLIAM HENRY, *Lt.-Colonel* R.E *ret.*	Malmesbury, Wilts.
✠	1900 Jan. 9.	HEARN, GORDON RISLEY, *Captain* R.E.	King, King and Co., Bombay.
	1881 Dec. 6.	HEATHORN, THOMAS BRIDGES, *Captain* R.A. *ret.*	10 Wilton Place, S.W. (Kams London.)
	1855 Feb. 6.	HEDGER, PHILIP	Couledon, The Avenue, Surbiton.
	1904 Jan. 12.	HEMINGWAY, CHARLES ROBERT	1 Brunel Terrace, Derby Roa Nottingham.
	1851 Apr. 1.	HILL, JULIAN	8 Dean's Yard, Westminster, S.W.
	1885 Dec. 1.	HILL, VINCENT WALKER	S. E. & C. D. Rys., London Brid Station, S.E.
	1876 Jan. 11.	HIME, *Rt. Hon. Sir* ALBERT HENRY, *Lt.-Colonel* R.E. *ret.*, K.C.M.G., P.C., LL.D. (*Edin.*)	Maritzburg, Natal.
	1876 May 30.	HODGSON, HENRY TYLSTON ..	Harpenden, Herts.
	1868 Dec. 1.	HOLGATE, JOHN THOMAS	Elmfield, Ashtead, Surrey.
	1881 Mar. 1.	HOLLINGS, JAMES SPENCER ..	249 Birchfield Rd., Handsworth, Staff
	1877 Mar. 6.	HOLME, ARTHUR HILL	6 Gambier Terrace, Hope Stree Liverpool.
✠	1886 Feb. 2.	HOPE, WILLIAM	10 Blackstock Street, Liverpool.
	1897 Mar. 2.	HOPKINSON, JOHN	Westwood, Watford.
	1867 Dec. 3.	HOWARD, JOHN	17 Victoria Street, S.W.
	1862 Jan. 14.	HUNT, HENRY ARTHUR	45 Parliament Street, S.W.
	1865 Apr. 4.	HUTCHINSON, ALFRED	62 Highbury Park, N.
	1874 Mar. 3.	HUTCHINSON, CHARLES SCROPE, *Maj.-Gen.* R.E. *ret.*, C.B. ..	14 Kidbrook Park Rd., Blackheat S.E.
	1858 Dec. 7.	ISAACS, LEWIS HENRY	3 Verulam Buildings, Gray's Inn, W.C
	1887 May 3.	JACKSON, *Sir* JOHN, F.R.S.E.	53 Victoria Street, S.W.
✠	1876 Feb. 1.	JACOB, *Sir* SAMUEL SWINTON, *Col. Indian Staff Corps*, K.C.I.E.	c.o. H. S. King & Co., Pall Mall, S.W
	1866 Feb. 6.	JAMES, FREDERICK	48 Tregunter Rd., Brompton, S.W.

Date of Election.	ASSOCIATES.	
C ✠ 1891 Dec. 1.	JARINTZOFF, DMITRI THEODOR, *General* I.R.N.	Admiralty, St. Petersburg.
1904 Apr. 12.	JARRAD, FREDERICK WILLIAM, *late Commander*, R.N.	Delamere, Bradwell-on-Sea, Essex.
1876 Apr. 4.	JEFFERIES, THOMAS	Newbay, Wexford.
1887 Dec. 6.	JORDAN, WILLIAM LEIGHTON	25 Jermyn Street, S.W.
1894 Dec. 4.	JUDD, JOSEPH HENRY	Ferncliffe, Hawthorn Grove, Heaton Moor, Lancs.
1901 Dec. 3.	KILBURN, BERTRAM EDWARD DUNBAR, M.A. (*Cantab.*)	111 Hatton Garden, E.C.
1871 Dec. 5.	LAMBERT, EDWARD TILEY, B.A. (*Cantab.*)	Telham Court, Battle.
1884 Dec. 2.	LASS, ALFRED	244 Upper Richmond Road, Putney, S.W.
1861 Mar. 5.	LEE, JOHN COCKBURN FRANCIS	42 Gloucester Gardens, Hyde Park, W.
1888 May 15.	LEWIS, HENRY FREDERICK WILLIAM	25 College Hill, Cannon Street, E.C.
1881 Feb. 1.	LINGARD-MONK, RICHARD BOUGHEY MONK	Great Central Ry., Manchester.
1897 Dec. 7.	LISBÕA, MIGUEL RIBEIRO, *Captain Brazilian Navy ret.*	Obras Municipaes, Belém, Brazil.
1877 May 1.	LITTLER, *Sir* RALPH DANIEL MAKINSON, C.B., K.C.	6 Pump Court, Temple, E.C. (Holborn 46.)
1883 Dec. 4.	LORIMER, WILLIAM	Glasgow Loco. Works, Glasgow.
1865 Mar. 7.	LOVATT, HENRY	Darlington Street, Wolverhampton.
1879 Dec. 2.	LUCAS, *Sir* ARTHUR CHARLES, *Bart.*	Broad Sanctuary Chambers, Westminster, S.W. (Loco. London. Westminster 61.)
1893 Jan. 10.	MACAULAY, FREDERIC JULIUS	L.&S.W.Ry., Waterloo Bridge, S.E.
1890 Dec. 2.	MCCORMICK, JOHN	West End, Brisbane, Queensland.
1873 Jan. 14.	MACKAY, JOHN	South Bank, Hereford.
1899 Jan. 10.	MACMORRAN, ALEXANDER, M.A. (*Edin.*), K.C.	3 Temple Gardens, E.C.
1872 Dec. 3.	MCNAIR, JOHN FREDERICK ADOLPHUS, *Major* R.A., C.M.G.	Scotia, Preston Park, Brighton.
1901 Dec. 3.	MAIA, ALFREDO EUGENIO ALMEIDA	Rua de S. Bento 34, Rio de Janeiro.
1888 May 15.	MANN, JAMES ROBERT, *Maj.-General* R.E. *ret.*, C.M.G.	Highfield Lodge, Tilehurst, Berks.
1865 Feb. 7.	MAPPIN, *Sir* FREDERICK THORPE, *Bart.*, M.P.	38 Prince's Gate, S.W.
1864 Apr. 5.	MARTIN, SAMUEL GARLICK	Halefield, Wendover, Bucks.
1892 Dec. 6.	*MARTIN, WILLIAM M.A., LL.D. (*Cantab.*)	Patent Office, Southampton Buildings, W.C.
1903 Mar. 3.	MATHIESON, JOHN	Duffield, Derbyshire.
1880 Dec. 7.	MATTHEY, GEORGE, F.R.S.	75 Hatton Garden, E.C.
1859 Apr. 5.	MEREDITH, JOHN BULT	9 Sydenham Road, Croydon.
1877 Apr. 10.	MIDDLETON, JOHN THOMAS	The Grange, Grange Road, Ealing, W. (Westminster, 693. Dislodge, London.)
1879 Apr. 1.	MILLYARD, JOHN WILLIAM	Littlebridge, Bromyard, Worcester.

	Date of Election.	ASSOCIATES.	
	1879 May 27.	MOBERLY, GEORGE ERNEST ..	Orwell Works, Ipswich. [W
m	1898 Dec. 6.	*MORRIS, JOHN TURNER	13 Somers Place, Hyde Park Squar
m	1873 May 20.	*MORT, FREDERICK HARRY ..	Parr's Bank, Widnes.
	1883 May 1.	MOULTON, JOHN FLETCHER, K.C., M.P.	57 Onslow Square, S.W.
	1877 May 1.	MOUSLEY, JAMES ALFRED ..	St. Germains, St. Albans.
	1879 May 6.	MOUSLEY, WILLIAM THOMAS ..	Combermere House, Buxton.

	1897 Feb. 2.	NARES, *Sir* GEORGE STRONG, K.C.B., *Vice-Admiral* ..	11 Claremont Road, Surbiton.
	1879 Dec. 2.	NEWMARCH, GEORGE, *Maj.-General* R.E. *ret.*	6 Norfolk Terrace, Brighton.
	1872 Dec. 3.	NICHOLSON, *Sir* WILLIAM GUSTAVUS, *Lieut.-General* R.E., K.C.B.	War Office, Pall Mall, S.W.
	1878 Feb. 5.	NOTMAN, HENRY WILKES ..	Cholmley Lodge, West End, Kilburn, N.W.

	1866 Mar. 6.	OAKLEY, *Sir* HENRY	G. N. Ry., King's Cross, N.
t ✠	1866 Feb. 6.	O'CONNELL, PETER PIERCE LYONS, *Maj.-Gen.* R.E. *ret.*	Sibertswold, Highland Road, Bromley, Kent.
	1868 Mar. 3.	OGILVIE, PATRICK	Hambledon, Hants.
	1901 Mar. 5.	OLIVER, CHARLES	Dept. of Railways and Tramways, Sydney, N.S.W.
	1898 Dec. 6.	OWEN, PERCY THOMAS, *Lt.-Col.* *N.S.W. Headquarters' Staff*	Commonwealth Military Headquarters, Melbourne, Victoria.

	1872 Apr. 9.	PAGET, BERKELEY	2 Laurence Pountney Hill, E.C.
	1891 May 12.	PAGET, *Sir* GEORGE ERNEST, *Bart.*	Sutton Bonnington, Loughborough.
	1877 Jan. 16.	PAIN, COARD SQUAREY	14 North John Street, Liverpool
	1891 Feb. 3.	*PAUL, ERNEST MONCREIFF, *Captain* R.E.	R.E. Institute, School of Military Engineering, Chatham.
	1895 Dec. 3.	PAULING, GEORGE CRAIG SAUNDERS	28 Victoria Street, S.W.
	1872 Dec. 3.	PAYNE, ALEXANDER	Norfolk House, Victoria Embankment, W.C.
	1878 Mar. 5.	PERKS, ROBERT WILLIAM, M.P.	11 Kensington Palace Gardens, W.
	1888 Dec. 4.	PERRY, WILLIAM ALFRED ..	2nd Avenue and 71st Street, Bay Ridge, Brooklyn, N.Y., U.S.
	1885 Apr. 14.	PESTONJEE, NOWROJEE	Ahmedabad, India.
T ✠	1860 Mar. 6.	PHILLIPS, JOSEPH	6 Radnor Park West, Folkestone.
	1862 Mar. 4.	PICKERING, JOHN	110 Lexham Gardens, S.W.
	1900 Apr. 3.	PICTON, REGINALD ERNEST, *Captain* R.E.	
	1869 Dec. 7.	POLLARD, CHARLES, *Lt.-General* R.E. *ret.*	c.o. Grindlay & Co., Parliament St., S.W.
	1897 Dec. 7.	PRICE, JOHN	15 Great George Street, S.W.
	1872 Jan. 9.	PYE-SMITH, ARTHUR . ..	St. Pancras Ironworks, N.W.

	Date of Election.	ASSOCIATES.	
	1891 Mar. 3.	RADCLIFFE, ALEXANDER NELSON	20 Craven St., Strand, W.C. (Dracliffe, London. Gerrard 2505.)
	1898 Jan. 11.	RADCLIFFE, PHILIP JOHN JOSEPH, *Captain* R.E. ..	R.E. Office, Royal Barracks, Dublin.
	1897 Dec. 7.	RAILTON, JAMES, JUN.	2 Great George Street, S.W.
	1899 Jan 10.	RANA, KUMAR NUR SINGH, *Bahadur*	Khatmandhu, Nepal, India.
	1883 Dec. 4.	RANDALL, JOSEPH	Warren Lane Works, Woolwich.
T t ✠	1872 Feb. 6.	REDGRAVE, GILBERT RICHARD	Thriffwood, Silverdale, Sydenham, S.E.
t ✠	1892 Jan. 12.	REDWOOD, BOVERTON, F.R.S.E.	4 Bishopsgate St. Within, E.C. (Oleflant, London.)
	1859 Feb. 1.	REID, JAMES	12 Wharf Road, City Road, N.
	1872 May 7.	*REYNOLDS, THOMAS	18 St. Swithin's Lane, E.C. (Reynolds, London.)
	1870 Mar. 1.	RICARDE - SEAVER, FRANCIS IGNACIO, *Major Argentine Govt. Service ret.*, F.R.S.E.	Athenæum Club, S.W.
	1871 Feb. 7.	RICKMAN, THOMAS MILLER ..	8 Montague St., Russell Square, W.C.
	1899 Jan. 10.	RIDLEY, THOMAS WILLIAM ..	Teresa Terrace, Coatham, Redcar.
	1895 Dec. 3.	ROBINSON, FREDERICK ARTHUR	54 Old Broad Street, E.C.
	1893 Apr. 11.	ROBINSON, JAMES CLIFTON ..	16 Great George Street, S.W.
	1859 May 3.	ROBINSON, JOHN	7 Carteret Street, Westminster, S.W.
	1868 May 5.	RYDON, HORACE JAMES	31 Highbury New Park, N.

	1882 May 23.	SALOMONS, *Sir* DAVID LIONEL, *Bart.*	49 Grosvenor Street, W.
	1884 Jan. 8.	SANKEY, *Sir* RICHARD HIERAM, *Lt.-Gen.* R.E. *ret.*, K.C.B. ..	32 Grosvenor Place, S.W.
	1869 Apr. 6.	SARGEAUNT, RICHARD ARTHUR, *Colonel* R.E. *ret.*	Westridge, Aspley Guise, Beds.
	1865 Dec. 5.	SCOTT, ARCHIBALD	L. & S.W. Ry., Waterloo, S.E.
	1883 Mar. 6.	SCOTT, *Sir* BUCHANAN, *Colonel* R.E., K.C.I.E.	c.o. Grindlay & Co., Parliament Street, S.W.
	1899 Feb. 7.	SCOTT, CHARLES THOMAS.. .	Manor House, Beckford, Tewkesbury.
	1868 May 5.	SCOTT-MONCRIEFF, *Sir* COLIN CAMPBELL, *Col.* R.E. *ret.*, K.C.S.I., K.C.M.G., LL.D. (*Edin.*)	11 Cheyne Walk, Chelsea, S.W.
	1892 Dec. 6.	SCOTT - MONCRIEFF, GEORGE KENNETH, *Lt.-Colonel* R.E., C.I.E.	King, King & Co., Bombay.
	1887 Dec. 6.	SCRATCHLEY, PHILIP ARTHUR, M.A. (*Oxon.*)	17 Victoria Street, S.W.
	1861 Feb. 5.	SILVER, HUGH ADAMS, *Col. ret.* 4 *Vol. Batt. Essex Regt.*	23 Redcliffe Square, Kensington, S.W.
	1897 Dec. 7.	SIMPSON, EDWARD PERCY, M.A. (*Oxon.*)	58 Kensington Gardens Square, W.
	1875 Apr. 6.	SMITH, CHARLES	Sir J. Gilbert, F.R.S., Harpenden, St. Albans.
	1888 Apr. 10.	SMITH, JOSEPH HENRY	St. Stephen's Club, Westminster, S.W.
	1878 Mar. 5.	SPENCER, SAMUEL	14 Great St. Thomas Apostle, E.C. (Tubes, London. Bank 296.)
	1896 Apr. 14.	SPILSBURY, EDGAR CHARLES, *Major* R.E.	East Devonport, Tasmania.
✠	1879 Mar. 4.	SQUIRE, JOHN BARRET	20 Victoria Street, Westminster, S.W.
	1862 Jan. 14.	STALBRIDGE, *Lord*, P.C.	Motcombe House, Shaftesbury.
	1898 Mar. 1.	STENNING, ALEXANDER ROSE ..	121 Cannon Street, E.C.

	Date of Election.	ASSOCIATES.	
	1871 Mar. 7.	STERNE, LOUIS	Donnington House, Norfolk Street W.C. (Elsterne, London. Gerrard 1989.)
	1895 Dec. 3.	STEVENS, GEORGE JAMES ..	61 Beulah Hill, Upper Norwood S.E.
	1874 Apr. 14.	STEWART, GILBERT MACLEOD	Kitterick, Woking.
	1893 Dec. 5.	STEWART, JAMES, *Major* R.E. *ret.*	4 King Street, St. James's, S.W.
	1902 Jan. 14.	STIRLING, JAMES	Tormore, Bayswater, Victoria.
t ✠	1862 May 6.	SUGG, WILLIAM THOMAS.. ..	Regency St., Westminster, S.W.
	1902 Feb. 4.	THALLON, JAMES FORSYTH ..	Railway Dept., Brisbane, Queensland.
	1883 Jan. 9.	THEOBALD, JOHN WILSON ..	8 Fairfield Road, Croydon.
	1879 Apr. 1.	*THOMPSON, *Sir* THOMAS RAIKES, *Bart.*	67 Cornhill, E.C.
	1859 May 3.	THOMSON, JOHN	Cluthа, Culverden Park, Tunbridge Wells.
	1880 Jan. 13.	TOPHAM, WILLIAM HAMPSON ..	2 Great George Street, S.W. (Canal, London.)
	1888 Mar. 6.	TRAUTWINE, JOHN CRESSON, Jr.	257 South 4th St., Philadelphia, U.S.
	1901 Dec. 3.	*TRAVERS, HENRY CECIL, *Lieut.* R.G.A.	Ordnance Office, Head Quarters, York.
	1885 Dec. 1.	TURNER, SAMUEL LUCAS ..	Placerville, El Dorado Co., Cal., U.S.
	1861 Mar. 5.	TYER, EDWARD	Ashwin Street, Dalston, N.E.
T t ✠	1853 May 3.	TYLER, *Sir* HENRY WHATELY, *Captain* R.E. *ret.*	Linden House, Highgate Road, N.W.
	1904 Apr. 12.	TYLER, WILLIAM FERDINAND	Shanghai, China.
	1868 Mar. 3.	VICKERS, ALBERT	28 Victoria Street, S.W.
	1869 Dec. 7.	VIGERS, ROBERT	4 Frederick's Place, Old Jewry, E.C.
	1862 Dec. 2.	WADDINGTON, JOHN	35 King William Street, E.C. (Bank 518.)
	1894 Dec. 4.	WALKER, CHARLES HAY.. ..	15 Great George Street, S.W.
	1866 Apr. 10.	WARREN, *Sir* CHARLES, *Lt.-General* R.E., G.C.M.G., K.C.B., F.R.S.	10 Wellington Crescent, Ramsgate.
	1898 Jan. 8.	WATSON, CHARLES HUBBACK	Johnson & Co., Greenhithe, Kent.
	1884 Dec. 2.	WATSON, *Sir* WILLIAM	25 Fitzwilliam Place, Dublin. (Watson, Dublin.)
	1867 May 7.	WAUGH, HENRY	195 South Croxted Road, West Dulwich, S.E.
	1871 Feb. 7.	WAUGH, JOHN	Sunbridge Chambers, Bradford (Powerful, Bradford. 72.)
	1879 May 6.	WESTERN, JAMES HALIFAX, *Lt.-Col.* R.E. *ret.*, C.M.G...	Broadway Chambers, Westminster, S.W.
	1904 Apr. 12.	WHARTON, *Sir* WILLIAM JAMES LLOYD, K.C.B., F.R.S. ..	"Florys," Princes Road, Wimbledon Park, S.W.
	1885 Feb. 3.	WHITAKER, WILLIAM, B.A. (*Lond.*), F.R.S.	Freda, Campden Road, Croydon.
	1872 Apr. 9.	WHITE, FREDERICK ANTHONY	72 Fenchurch Street, E.C. (Avenue 5690.)
	1872 Apr. 9.	WHITE, LEEDHAM	16 Wetherby Gardens, S.W.
	1874 Dec. 1.	WILDE, SAMUEL JOHN	10 Serjeants' Inn, Fleet Street, E.C.
	1888 Dec. 4.	WILLCOX, BENJAMIN	47 Lincoln's Inn Fields, W.C.
	1874 Apr. 14.	WILSON, *Sir* ALEXANDER, *Bart.*	Cyclops Works, Sheffield.

Date of Election.	ASSOCIATES.	
1901 Dec. 3.	WINN, JOHN, *Major* R.E. ..	School of Military Engineering, Chatham.
1872 Apr. 9.	WISE, *Sir* WILLIAM LLOYD ..	46 Lincoln's Inn Fields, W.C. (Lloyd Wise, London. P.O. Telephone—Central 4775.)
1877 Dec. 4.	WOODHEAD, WILLIAM BOOTH ..	18 Exchange, Bradford.
1876 May 2.	WOODHOUSE, THOMAS WALTER	35 & 36 Red Lion Square, W.C.
1874 Mar. 3.	WOODS, ARTHUR	18 Kensington Gardens Terrace, W.
1857 May 19.	WRIGHT, JOSEPH	Gresham Club, Gresham Place, E.C.
1882 Dec. 5.	YERBURGH, JOHN EARDLEY ..	21 Queen Anne's Gate, S.W.
1886 Feb. 2.	YOUNG, CARMICHAEL LIGHT, *Col.* R.E.	Haileybury College, Hertford.
1891 Dec. 1.	YOUNG, JOHN PRATT	Brent Knoll, Chantry Road, Moseley, Birmingham.
1877 Feb. 6.	YOUNG, SEPTIMUS	5 Victoria Street, S.W.

Total number of Associates .. .. 275.

STUDENTS.

[Stud. Inst. C.E.]

Date of Admission.	STUDENTS.	
1904 Mar. 22.	ABBATT, FRANK WARNER ..	33 Mattock Lane, Ealing, W.
1900 Jan. 9.	ABLETT, CHARLES ANTONY ..	General Electric Co., Schenectady, U.S.
1900 Nov. 27.	ADAMS, FREDERICK GUY TRE-VENNER	10 Tavistock Road, Croydon.
1900 Dec. 18.	ADCOCK, CECIL PHILIP	Serrano 98, Madrid.
1902 Mar. 25.	AHSAN, MOHOMED	Saifabad, c.o. Nawab Vicar Nawar Jing, Hyderabad, Deccan.
1901 Dec. 17.	AITKEN, KENNETH EDMONDSTONE	Engineer's Office, Crigglestone, Wakefield.
1901 Feb. 26.	ALDERSMITH, CLAUDE HERBERT	Stammerham, West Horsham.
1904 Mar. 15.	ALDOUS, FREDERICK GRAY ..	John Mowlem & Co., 19 Grosvenor Road, S.W.
1901 Apr. 23.	ALEXANDER, CONNELL WILLIAM LONG, B.E. (*Royal*)	430 Moseley Road, Birmingham.
1903 Mar. 24.	ALEXANDER, JOHN EDWARD ..	37 Woodberry Grove, Finsbury Park, N.
1899 Nov. 28.	ALLAN, HARRY ALFRED ROBERT	
1902 Dec. 16.	ALLEN, GEORGE JAMIESON ..	Works Dept., H.M. Dockyard, Malta.
1903 Mar. 24.	ALLEN, GEORGE READ	Annandale, Stretford.
1898 Dec. 20.	ALLEN, RUPERT STANLEY ..	Bromham House, Bromham, Bedford.
1903 Mar. 24.	ALLIN, RUSSELL VINCENT ..	G. N., Piccadilly & Brompton Ry., 6 Belgrave St., King's Cross, N.
1900 Mar. 27.	ALLOTT, CHARLES WILLIAM ..	Erlsmere, Old Trafford, Manchester.
1904 Mar. 29.	AMOORE, HENRY JAMES	Public Offices, Southall.
1903 Nov. 10.	ANDERSON, ALEXANDER	41 Whittingstall Road, S.W.
1899 Nov. 28.	ANDERSON, HENRY	Foster & Co., Portmadoc.
1898 Mar. 29.	ANDERSON, JOHN ARMSTRONG	
1903 Jan. 27.	ANDOE, HILARY REGINALD .	2 Elliot Terrace, The Hoe, Plymouth.
1903 Mar. 10.	ANDREWS, EWART SIGMUND ..	79 Aberdeen Road, Highbury.
1903 Nov. 10.	ANGUS, ROBERT JOHN	9 Findhorn Place, Edinburgh.
1899 Nov. 28.	ANNEAR, ROBERT LEE	Grasmere, Cathedral Road, Cardiff.
1900 Mar. 27.	ANTINORI, JOHN CHARLES ..	Pauling & Co., Box 713, Cape Town, C.C.
1901 Dec. 11.	APPLETON, FRANCIS CASS ..	Rawden Hill, Arthington, Leeds.
1900 Nov. 27.	APTED, FRANK EARDLEY ..	County Engineer's Dept., Guildhall. Westminster, S.W.
1900 Mar. 27.	ARGYLE, REGINALD EDWARD VERE	Engineer's Office, Midland Railway. Derby.
1901 Dec. 11.	ARIES, RONALD BUGLER	S. Pearson & Son, 32 Pier Street West Hoe, Plymouth.
1899 Nov. 28.	ARMSTRONG, ALFRED HENRY, B.Sc. (*Edin.*)	115 University Street, Belfast.
1902 Dec. 2.	ARNEIL, HENRY MOFFAT ..	57 Belmont Road, Portswood, Southampton.
1903 Nov. 24.	ARNOTT, CHARLES DUDLEY ..	Seacroft, The Cliffs, Gorleston.
1899 Nov. 28.	ARTHUR, ROBERT	11 Gibbons Road, Bedford.
1900 Jan. 9.	ARUNDEL, FRANK DREW ..	2 Shady Villas, Erith.
1899 Nov. 28.	ASTBURY, ARTHUR RALPH ..	P.W.D., Abbottabad, Punjab.

Date of Admission.	STUDENTS.	
1902 Nov. 5.	Atcherley, Lewis Winter ..	13 Hinde St., Manchester Square, W.
1900 Nov. 27.	Atkins, Malcolm Ramsay ..	8 Holt Villas, Alvaston, Derby.
1901 Dec. 11.	Ayris, Henry Hawksley ..	30 Great George Street, S.W.
1902 Dec. 9.	Bacon, Francis	Earlstone, Newbury.
1900 Nov. 27.	Bacon, Frederic	Melbourne, Park Avenue, Ashton-on-Mersey.
1904 Mar. 29.	Baddeley, George Henry ..	Lonsdale Villa, Binley Road, Coventry.
1904 Mar. 29.	Baillie, Thomas Hamilton ..	3 Chichester Street, Pimlico, S.W.
1899 Nov. 28.	Bain, Harold Brooklyn ..	Lealholme, Great Crosby, Liverpool.
1903 Nov. 24.	Baines, George Norman ..	Engineer's Office, N.E. Ry., York.
1904 Feb. 9.	Baissac, Charles Maurice ..	Central Technical College, Exhibition Road, S.W.
1902 Dec. 9.	Baker, John Alfred	Royal Indian Engineering College, Staines.
1902 Dec. 9.	Baker, Lucius Aveling ..	S. Pearson & Sons, Obras del Puerto, Salina Cruz, Oaxaca, Mexico.
1903 Nov. 17.	Balding, Charles John ..	4 Glenton Road, Lee, S.E.
1904 Mar. 29.	Ball, Ernest	26 Riding Street, Southport.
1901 Nov. 19.	Ball, James Dudley Ward ..	Engineer's Office, L. & N.W. Ry., Crewe.
1900 Mar. 13.	Ballantyne, William Henry, B.Sc. (*Glas.*)	111 Hatton Garden, E.C.
1903 Nov. 17.	Balston, Francis William, B.A. (*Cantab.*)	James Simpson and Co., 101 Grosvenor Road, S.W.
1903 Nov. 24.	Banister, Walter George ..	19 Norland Square, Notting Hill, W.
1904 Mar. 29.	Barber, Sydney Stuart .	7 Rue du Parlement, Liége, Belgium.
1904 Mar. 29.	Barker, Arthur Stanley ..	Ashleigh, Horbury, Leeds.
1903 Mar. 24.	Barlow, Alfred	35 Trinity Street, Huddersfield.
1903 Nov. 24.	Barnes, Leslie Holding ..	1 Mechlin Mansions, Brook Green, W.
1900 Dec. 18.	Barnett, Cecil Guy	P. W. D., Mandalay, Burma.
1898 Mar. 29.	Barnwell, Frederick Arthur Lowry	Stramshall Vicarage, Uttoxeter.
1902 Mar. 25.	Barrack, John Charles ..	Ewell Road, Epsom.
1904 Mar. 29.	Barry, Arthur Paul ..	King's College, Strand, W.C.
1898 Dec. 20.	Barry, Kenneth Alfred Wolfe	4 Embankment Gardens, Chelsea, S.W.
1902 Nov. 25.	Bartlett, Godfrey Thomas	20 Victoria Square, S.W.
m ✠ 1897 Nov. 10.	Bartlett, Hardington Arthur	12 Cautley Avenue, South Side, Clapham Common, S.W.
1903 Mar. 24.	Barton, Geoffrey Butler ..	16 Linnæus Street, Hull.
1902 Dec. 2.	Basta, Habeeb	Robey & Co., Lincoln.
1903 Dec. 22.	Batson, Reginald George Cyril	King's College, Strand, W.C.
1902 Nov. 5.	Battle, Philip Marfleet ..	Roundhill Reservoir, Healy, Masham, Yorks.
1903 Mar. 17.	Baxter, Harold Hosier ..	70 Thornfield Road, Uxbridge Road, W.
1902 Nov. 5.	Bayley, Francis Edmund, B.A. (*Cantab.*)	188 Heaton Road, Heaton, Newcastle-on-Tyne.
1898 Nov. 22.	Bayley, Victor	41 Bath Road, Swindon.
1901 Mar. 26.	Baynes, Ronald Christopher	Engineer's Office, G. W. Ry., Paddington, W.
1903 Mar. 24.	Beaumont, Arthur Gregory	Highgate, Beverley, East Yorks.
1902 Mar. 25.	Beaumont, Roland Hirst ..	Holme Lea, Grenoside, Sheffield.
1899 Nov. 28.	Beazley, Arthur Tetley ..	1 Elborow Street, Rugby.

Date of Admission.	STUDENTS.	
B 1903 Nov. 24.	BECHER, LANCELOT EDWARD ..	Royal Indian Engineering College, Staines.
1899 Nov. 28.	BEDBROOK, ERNEST ARTHUR ST. GEORGE	35 Emanuel Avenue, Acton.
1903 Mar. 24.	BEDFORD, FREDERICK GORDON HAY	Beech Grove, Benton, Newcastle-on Tyne.
1903 Dec. 22.	BEGGS, GEORGE ARTHUR ..	24 Mecklenburgh Square, W.C.
1902 Nov. 5.	BEILES, JAMES LOUIS	22 Rectory Rd., Stoke Newington, N.
1899 Nov. 28.	BELDAM, ERNEST ASPLAN ..	The Limes, Hounslow.
1899 Nov. 28.	BELL, JAMES MALCOLM, B.Sc. (*Glas.*)	11 Westbourne Gardens, Glasgow.
1900 Nov. 27.	BELOE, WILFRID	Henfache, Llanrhaiadr, Oswestry.
1904 Feb. 9.	BENDER, WILLIAM EDWARD GUSTAVE	152 Rosendale Road, West Dulwich, S.E.
1897 Feb. 16.	BENDLE, WILLIAM GEORGE ..	British Central Africa Co., Chiromo, British Central Africa.
1902 Mar. 25.	BENNETT, DOUGLAS RAYMOND	L. & S.W. Ry., Eastleigh, Hants.
1902 Mar. 25.	BENNETT-POWELL, PERCIVAL GORDON	Normanhyrst, Harlesden, N.W.
1904 Mar. 29.	BENTALL, ROBERT ANTHONY ..	Borough Engineer's Office, Worthing.
1897 Nov. 23.	BERRIDGE, HAROLD MEREDITH KING	Surveyor's Office, Long Eaton, Notts.
1903 Mar. 24.	BERRIMAN, ALGERNON EDWARD	130 Cardigan Terrace, Heaton, Newcastle-on-Tyne.
1901 Dec. 11.	BEST, ALFRED JOHN	25 Elmwood Road, Herne Hill, S.E.
1901 Mar. 26.	BEVAN, CORBY GARLAND ..	The Ferns, Haddenham, Bucks.
1899 Nov. 28.	BIDDER, MAURICE McCLEAN ..	c/o H. F. Bidder, 10 Queen's Gate Gardens, S.W.
1904 Mar. 22.	BIDEN, SODEN WILLIAM	Bahadurganj, Gonda District, N.W.P., India.
1902 Nov. 5.	BILGRAMI, SYED MUJTABA ALI	King, King & Co., Bombay.
1903 Nov. 10.	BLABER, REGINALD	Southdown Road, Shoreham, Sussex.
1902 Dec. 2.	BLAKER, CHARLES EDWARD ..	Riverside, Leam Terrace, Leamington.
1902 Mar. 18.	BLAND, CHARLES ROXBERRY ..	11 Brondesbury Park, N.W.
1900 Dec. 18.	BLENKINSOP, BERNARD ARTHUR	
1902 Dec. 2.	BLOMFIELD, EDWARD VALENTINE	Engineer's Office, N. E. Ry., Central Station, Newcastle-on-Tyne.
1900 Mar. 27.	BLYTH, BENJAMIN HALL, Jun.	135 George Street, Edinburgh.
1899 Nov. 28.	BOND, HERBERT IVO DE KENTON	156 Ashley Gardens, S.W.
1901 Feb. 26.	BOOTHROYD, JOSEPH	32 Hallfield Road, Bradford.
1903 Nov. 10.	BORNS, GEORGE WILLIAM MAXIMILIAN	Gloriastrasse 66, Zürich, Switzerland.
1898 Aug. 30.	BORROW, FRANK KENDALL ..	38 Nevern Square, Earl's Court, S.W.
1897 Mar. 15.	BOSTOCK, JOHN EDWARD ..	Admiralty Harbour Works, Dover.
1902 Nov. 25.	BOSWALL, ROBERT OLIPHANT	4 Evelyn Road, Richmond, Surrey.
1899 Nov. 28.	BOULTON, GEORGE STOREY ..	Croft House, Roose, Barrow-in-Furness
1903 Feb. 3.	BOWEN, SYDNEY	39 Heath Hurst Road, Hampstead, N.W.
1897 Dec. 21.	BOWERS, PERCY LLOYD	P.W.D., Sirur, Poona, India.
1902 Apr. 8.	BOWLER, FREDERICK THOMAS.	G.W.Ry., Engineer's Office, Neath.
1902 Nov. 5.	BOWLER, LIONEL VICTOR ..	
1898 Nov. 8.	BOWREY, JAMES MILNE	52 Vesta Road, Brockley, S.E.
1901 Nov. 19.	BOYD, ARTHUR, B.Sc. (*Sydney.*)	24 Gordon Street, Gordon Square W.C.
1901 Nov. 19.	BOYD, FIELDING CHARLES ROBERT HATLEY	Natal Cape Railway, Elandskop, Natal.
1903 Mar. 24.	BRADFORD, JOHN HOWARD PENNY	32 Gratton Road, West Kensington.
1900 Mar. 27.	BRADLEY, CECIL GUSTAV ..	Town Hall, Barrow-in-Furness.

Date of Admission.	STUDENTS.	
1903 Nov. 24.	BRADLEY, CHARLES HENRY ..	47 Beeches Road, West Bromwich.
1903 Nov. 10.	BRAILSFORD, HAROLD SUGDEN	Kemnal Manor, Chislehurst.
1903 Mar. 24.	BRAMHAM, WILLIAM CAMPBELL	68 Camberwell Grove, S.E.
1901 Nov. 19.	BREBNER, ALEXANDER	28 Hermitage Gardens, Edinburgh.
1901 Jan. 8.	BRERETON, CHRISTOPHER FRANCIS SWIFT	4 Park View Terrace, Portslade, Brighton.
1900 Nov. 27.	BRIETZCKE, EDMUND HENRY ..	19 Cornelia Terrace, Seaham Harbour, co. Durham.
1904 Mar. 29.	BRIGGS, RICHARD JOHN PERCIVAL	47 Victoria Street, S.W.
1903 Mar. 24.	BRIGHT, ARTHUR KINGSLEY ..	Lea Hurst, Mapperley Road, Nottingham.
1902 Mar. 25.	BRISTOW, ALFRED HENRY ..	Antwerp House, Belgrave Road, Cambridge.
1899 Nov. 28.	BROOKES, WILLIAM ROBERT PHILPOT	Rodmersham Green Post Office, Sittingbourne.
1904 Mar. 29.	BROOM, TALBOT COTTOM ..	Greenbank, Rainhill, Lancs.
1900 Apr. 3.	BROOMFIELD, FRANK	97 High Street, Redcar.
1899 Mar. 7.	BROUNGER, WILLIAM HENRY PRESCOTT	Engineer's Office, Dock Works, Grangemouth, N.B.
1898 Mar. 29.	BROWN, CUTHBERT CHALMERS	4 Portland Place, Leek.
1903 Mar. 24.	BROWN, THOMAS STANLEY ..	68 Palatine Road, West Didsbury.
1898 Nov. 29.	BROWNE, DENIS ROBERT HOWE	Grindlay, Groom & Co., Bombay.
1902 Dec. 2.	BUCHANAN, LAWRENCE GORDON	Colyton, Bromley, Kent.
1897 Nov. 10.	BUCKLAND, GEORGE FREDERIC	Waterdale, Westbury-on-Trym.
1898 Dec. 20.	BUCKNEY, THOMAS WILLIAM ..	37 Finsbury Park Road, N.
1899 Nov. 28.	BULL, EDWIN MASSEY	Surveyor's Office, Church End, Finchley, N.
1898 Nov. 22.	BULLIVANT, FRANK	The Willows, Lees, Oldham.
1902 Dec. 2.	BULLOCK, FRANK HARRISON ..	67 King Street, Manchester.
1902 Nov. 5.	BURKITT, FRANCIS HOLT ..	Jhelam Canal, Sarghoda, Punjab.
1898 Nov. 22.	BURMAN, JOHN HAROLD, M.Sc. (*Victoria*)	Engineer's Office, L. & Y. Ry., Manchester.
1903 Mar. 24.	BURNET, JAMES	16 Charles Street, Langholm.
1903 Nov. 24.	BURR, FRANCIS WILLIAM MANFRED	99 Belvedere Road, Upper Norwood, S.E.
1898 Mar. 29.	BURTON, RICHARD	25 Old Bank Buildings, Chester.
1901 Nov. 19.	BURTON, WILLIAM ARTHUR ..	Thos. Firth & Sons, Norfolk Works, Sheffield.
1903 Mar. 24.	BURTON, WILLIAM MAINWARING	17 The Causeway, Horsham.
1904 Mar. 29.	BURY, RONALD EDWARD ..	8 Hightown, Crewe.
1898 Nov. 22.	BUTLER, JOSEPH FAWKNER ..	Brookland, Jesmond Park, Newcastle-on-Tyne.
1903 Mar. 24.	BUTLER, RALPH WILLIAM ..	Boro' Surveyor's Office, Devonport.
1903 Nov. 24.	BUTLER, ROBERT THOMAS ROWLEY PROBYN	Royal Indian Engineering College, Staines.
1899 Mar. 28.	BUTTERFIELD, HERBERT MITCHELL	S. Tomlinson, 1 Raffles Place, Singapore, S.S.
1899 Mar. 28.	BYWATERS, STANLEY HAYDON	N.E. Railway, Gowthope, Selby.
1902 Dec. 2.	CABLE, FREDERIC WILLIAM ..	C. N. Lailey, 6 The Sanctuary, Westminster, S.W.
1898 Dec. 20.	CALVI, ALBERTO ULISSE	Cairo.
1898 Nov. 8.	CAMPBELL, COLIN STUART ..	Main Drainage, Chertsey, Surrey.
1900 Mar. 27.	CAMPBELL, HUGH	Engineer's Office, Caledonian Ry., Glasgow.
1899 Nov. 28.	CAMPBELL-BAYARD, STEPHEN	Cotswold, Wallington, Surrey.
1903 Mar. 24.	CAPITO, CHARLES ERIK	5 Eardley Crescent, Earl's Court, S.W.
1903 Mar. 24.	CARLETON, HUGH THOMAS ..	Westlands, Cupar.
1903 Nov. 10.	CARMICHAEL, ARCHIBALD ..	48 Barons Court Road, W. Kensington, W.

	Date of Admission.	STUDENTS.	
	1903 Mar. 24.	Carr, Christopher Ralph ..	Wood House, Twerton-on-Avon Bath.
	1904 Mar. 29.	Carron, Frank Grant ..	H.M. Breakwater, Portland.
	1902 Mar. 25.	Carter, Dansie William ..	Charing Cross, Euston and Hampstead Ry., 20 Victoria Street, S.W.
	1903 Nov. 24.	Carter, Thomas Birchall ..	Royal Indian Engineering College, Staines.
	1901 Jan. 22.	Carty, Samuel Wilfrid ..	11 Ridley Place, Newcastle-on-Tyne.
	1901 Nov. 19.	Case, Gerald Otley	Case Sea Defence Syndicate, 104, High Holborn, W.C.
	1902 Nov. 5.	Chalmers, Charles Stuart, B.Sc. (*Victoria*)	101 Wilmslow Road, Withington, Manchester.
	1903 Nov. 10.	Chalmers, Robert, B.Sc. (*St. Andrews*)	Rotherwood, West Newport, Fife, N.B.
	1904 Mar. 22.	Chapman, Fitzroy Tozer, B.Sc. (*Lond.*)	4 Whingate, Armley, Leeds.
	1901 Mar. 26.	Chappell, Edwin	Red Cottage, Weybridge.
	1902 Nov. 18.	Chesterfield, Edward Percy	L. D. & E. C. Ry., Chesterfield.
	1904 Mar. 29.	Chippindale, Isaac Murray	Scholes, near Leeds.
	1903 Nov. 17.	Churcher, William Roy Milton	James Simpson and Co., 101 Grosvenor Road, S.W.
	1901 Nov. 27.	Chyn	c.o. Chow Phya Surawmgse, Klong Ban Somdet, Bangkok, Siam.
	1899 Feb. 21.	Clark, Albert Hawkins ..	Fishguard and Rosslare Railways, Fishguard Bay, South Wales.
	1901 Mar. 26.	Clark, Colin	Douglas Clark, Senekal, Orange River Colony.
	1903 Nov. 17.	Clark, David	1 Market Street, Aberdeen.
	1902 Nov. 18.	Clark, James Miller, M.A., B.Sc. (*Glas.*)	8 Park Drive West, Glasgow.
	1901 Dec. 3.	Clark, Robert George ..	18 Hendy Street, Roath Park, Cardiff.
	1903 Mar. 24.	Clarke, Ashford Vincent ..	5 Meyrick Crescent, Colchester.
	1903 Nov. 10.	Clarke, Ernest	The Beeches, Upton Park, Chester.
	1903 Nov. 24.	Clarke, Geoffrey	Royal Indian Engineering College, Staines.
	1901 Nov. 19.	Clarke, Reginald Hawley ..	17 Elmdale Rd., Tyndall's Park, Bristol.
	1902 Dec. 16.	Clarke, William Johnson ..	Melrose, London Road, Redhill.
m	1899 Nov. 28.	Clay, William Henry Christy	Midland Ry., Engineer's Office, Derby.
	1903 Nov. 10.	Clayden, Arthur Ludlow ..	St. John's, Exeter.
	1902 Jan. 21.	Clifford, Arthur Campbell	c.o. E. T. Clifford, 6 Cranley Gardens, South Kensington, S.W.
	1902 Jan. 21.	Close, Arthur Melvill ..	P.W.D., Dehra Doon, India.
	1903 Mar. 24.	Clough, Frederick Harold ..	2 Victory Terrace, Parliament Road, Middlesbrough.
	1898 Oct. 6.	Clough, Frederick Horton	British Thomson-Houston Co., Rugby.
	1903 Mar. 24.	Cochrane, Morton Farrer ..	140 West George Street, Glasgow.
	1904 Mar. 29.	Cochrane, William Henry ..	66 Warwick Rd., S. Kensington, S.W.
	1903 Nov. 17.	Cockburn, Henry	37 Fairfax Road, Bedford Park, W.
	1899 Nov. 28.	Colbourne, Rupert Lionel ..	Cook & Son, 13 Esplanade Road, Bombay.
	1899 Nov. 28.	Cole, Edward Onslow	8 Beech House Road, Croydon.
m	1900 Mar. 27.	Collett, John Colet	Midland Ry., Heysham Harbour, Morecombe.
	1900 Mar. 27.	Collins, Harold	City Engineer's Office, Norwich.
	1904 Mar. 15.	Collins, Robert Hayes ..	69 Ritherdon Road, Balham, S.W.
	1901 Nov. 19.	Collins, William Alfred ..	9 Oldfield Terrace, Acton Vale.
	1903 Mar. 24.	Colman, Alan	
	1898 Nov. 8.	Colyer, Cecil Alfred ..	Western Jumna Canal, Kainal.
	1900 Nov. 27.	Connor, James Johnstone ..	61 Albert Road, Crosshill, Glasgow.

Date of Admission.	STUDENTS.	
1899 Nov. 28.	COOK, JAMES	20 Iona Place, Mount Florida, Glasgow.
1904 Mar. 29.	COOPER, WILLIAM GODFREY ..	Coonoor, The Grove, Finchley, N.W.
1903 Mar. 31.	COOPER-KING, MAXIMILIAN KNIGHT	Kingscote, Egham Hill, Surrey.
1900 Feb. 13.	COPE, HERBERT AMBROSE, B.Sc. (*Victoria*)	The Croft House, Ashbourne Road, Derby.
1903 Nov. 10.	COPPOCK, HARRY STOWE, B.Sc. (*Wales*)	Structural Ironwork Dept., G.W. Ry., Paddington, W.
1900 Nov. 27.	CORADINE, WILLIAM ALEXANDER	Boro' Engineer's Office, Bethnal Green, N.E.
1900 Dec. 18.	CORNELIUS, EUSTACE HERBERT	P.W.D., Agra Canal, Muttra, India.
1904 Apr. 12.	CORTIS, HERBERT BRUCE ..	2 Garway Road, Bayswater, W.
1903 Nov. 24.	CORY, EDGAR MYRIE	19 Palace Mansions, Addison Bridge, Kensington, W.
1902 Feb. 4.	COTTEW, CHARLES HAROLD ..	3 Montague Gardens, Castle Avenue, Dover.
1902 Dec. 16.	COTTON, CHARLES GEOFFREY ..	Abbotsford, Cranbury Road, Eastleigh, Hants.
1900 Nov. 27.	COX, HENRY ASHLEY	Osbourne, New Town Road, Colchester.
1902 Nov. 5.	COX, REGINALD CHARLES, B.A. (*Cantab.*)	Marsland, Price & Co., Mazagon, Bombay.
1897 Feb. 23.	CRAIG, WILLIAM HENRY PRYSE	5 John Dalton Street, Manchester.
1902 Jan. 28.	CRAWFORD, LEONARD GEORGE	Vickers, Sons & Maxim, Barrow-in-Furness.
1904 Mar. 29.	CREAGH, HAROLD	98 Chorley New Road, Horwich.
1903 Nov. 24.	CREEDY, HAROLD DOUGLAS ..	19 Webster Gardens, Ealing, W.
m ✠ 1898 Jan. 25.	CRIDLAN, JOHN LIONEL	Maisemore Park, Gloucester.
1903 Nov. 10.	CRIPPS, RICHARD HARRISON ...	2 Stratford Place, Oxford Street, W.
1904 Mar. 29.	CROSS, ARTHUR LESLIE ROWBOTHAM	Glendale, School Road, Moseley.
1900 Apr. 10.	CRUM, JAMES ARTHUR	9 Hillhead Gardens, Glasgow.
1904 Mar. 29.	CRUMP, EDWIN SAMUEL ..	36 Margaretta Terrace, Oakley Street, Chelsea, S.W.
1901 Nov. 19.	CRYER, EDWARD	W. Vallance, 2 Fir Park Terrace, Dennistoun, Glasgow.
1899 Mar. 21.	CUÉ, BALTASAR FERNANDEZ ..	Llanes, Asturias, Spain.
1899 Mar. 7.	CULL, JOHN ERNEST LELLIOT	Canterbury College, Christchurch, N.Z.
1902 Mar. 25.	CURRIE, HUGH BOWDEN	48 Jesmond Rd., Newcastle-on-Tyne.
1898 Mar. 22.	DALE, BENJAMIN HERBERT ..	
1902 Dec. 2.	DĀNI, DĀMODAR GANESH, B.Sc. (*Bombay*), F.C.H. ..	Dr. Dāni, Sholapur, Bombay.
1903 Dec. 22.	DANIELL, OLIVER CARL	32 Cranbourne Street, Leicester Square, W.C.
1903 Feb. 17.	DARBY, EDWARD HENRY D'ESTERRE, B.A. (*Cantab.*)	The Osiers, Chiswick Mall, Middlesex.
1902 Nov. 5.	DARLEY, BERNARD D'OLIER ..	Ferney, Stillorgan, co. Dublin.
1900 Nov. 27.	DASHWOOD, ARTHUR PAUL ..	27 Maison Dieu Road, Dover.
1903 Mar. 24.	DAVEY, ARCHIBALD HENRY PINGSTON	E. M. Eaton, 28 Victoria Street, S.W.
1903 Jan. 20.	DAVID, CHARLES JOHN EVAN, B.A. (*Oxon*)	The Hendrê, Llandaff, Cardiff.
1904 Mar. 29.	DAVIDSON, DUNCAN CALVIN KNOX	Schoolhouse, Dunmaglass, by Inverness.
1903 Jan. 13.	DAVIDSON, WILLIAM ROBERT ..	Engineer's Office, Railways, Wellington, New Zealand.
1903 Nov. 24.	DAVIES, DAVID TUDOR	St. George's House, St. George's Terrace, North Road, Plymouth.

Date of Admission.	STUDENTS.	
1903 Jan. 13.	Davies, Ivor Parry	Holme Bank Cottage, Chester.
1902 Dec. 9.	Davies, St. John Alexander	Brampford Speke, Exeter.
1903 Nov. 10.	Davies, Theophilus Maxwell, B.A. (*Cantab.*)	79 Margaret Street, Cavendish Square, W.
1902 Nov. 11.	Davis, George Keville, B.Sc. (*Victoria*)	Sandilands, Knutsford.
1902 Mar. 25.	Davis, John Darelan David	27 Memorial Road, Walkden, Manchester
1902 Nov. 5.	Davison, Arthur	Springfield, Buttevant, co. Cork.
1900 Nov. 27.	Dawson, George Herbert Wrigley, M.A. (*Cantab.*) ..	"Woodlands," Horsforth, near Leeds.
1899 Nov. 28.	Dawson, Humphrey Francis	Madura Club, Madura, Madras.
1901 Nov. 19.	Deacon, Martin	19 Warwick Square, S.W.
1899 Nov. 28.	Dean, Edward Harold ..	City Hall, Westminster.
1902 Feb. 11.	Dean, Sydney Hembry ..	Boro' Engineer's Office, Blackburn
1903 Nov. 10.	De Lautour, Edgar	11 Mosedale Road, Rice Lane, N. Walton, Liverpool.
1899 Nov. 28.	Dennis, Randal Hamilton ..	Muftigong P.O., Jaunpur, U.P. India.
1903 Mar. 31.	Denton, Charles Murray ..	E. Bailey Denton, 9 Bridge Street Westminster, S.W.
1901 Nov. 27.	Devenish, William Roberts	Engineer's Office, White River Ontario, Canada.
1901 Jan. 22.	Dickenson, Walter Henry, B.Sc. (*Durham*)	4 Cavendish Place, Jesmond-on-Tyne.
1899 Nov. 28.	Dickinson, John Gilbert ..	79 Rice Lane, Egremont, Cheshire.
1898 Nov. 22.	Disley, Herbert Roston ..	Knot Hill House, Stacksteads Manchester.
1900 Dec. 18.	Dixon, Edward	British Royal Commission, St. Louis Exhibition, U.S.
1904 Mar. 29.	Dixon, Ernest	Admiralty Dockyard, Keyham Devonport.
1901 Dec. 11.	Dixon, Frank..	Dixon & Co., 5 Cheapside, Bradford, Yorks.
1900 Nov. 27.	Dixon, John Leonard ..	35 Royal Avenue, Chelsea, S.W.
1903 Mar. 24.	Dobree, Hatherley Moor ..	West Tilbury Rectory, Tilbury.
1903 Nov. 10.	Dobson, Ernest	Waldon Castle, Torquay.
1902 Dec. 9.	Dodson, Charles Sherborne	Bonchurch, Ipswich Road, Norwich
1901 Jan. 22.	Donald, Robert Buchan ..	Kilbowie Cottages, Clydebank, Glasgow.
1901 Dec. 11.	Down, Stafford William ..	Govt. Rys., King William's Town, Cape Colony.
1900 Dec. 18.	Du Cane, Charles George, B.A. (*Cantab.*)	New Dock Works, Middlesbrough.
1897 Nov. 10.	Duckham, Arthur McDougall	Gasworks, Bourne Valley, Bournemouth.
1904 Feb. 9.	Duffield, Henry Charles, B.A. (*Cantab.*)	27 Holland Park, W.
1900 Nov. 27.	Duke, Basil Michael ..	52 Corporation Street, Stafford.
1899 Nov. 28.	Dumbleton, Jocelyn Charles	Royal Survey Dept., Bangkok, Siam.
1901 Nov. 27.	Duncanson, Alexander Walker	16 Deane Road, Fairfield, Liverpool.
1901 Apr. 23.	Dunwoody, Robert Browne	Royal Commission on London Traffic, 36 Great George St., S.W.
1904 Mar. 29.	Dusautoy, Edward Frank ..	Trevayler, Burton Road, Derby.
1904 Mar. 29.	Dutton, George Edward ..	The Vines, Thorburn Road, New Ferry, Birkenhead.
1903 Nov. 24.	Dymock, John Dobie Halliday	2 Grafton Square, Glasgow.
1903 Nov. 24.	Dyson, Arthur	59 High Street, Harborne.
1903 Nov. 24.	Dyson, Hubert	Esholt, Roundhay, Leeds.

	Date of Admission.	STUDENTS.	
	1903 Dec. 22.	EASSON, GEORGE ALEXANDER ..	16 George Street, Coupar Angus.
	1900 Mar. 27.	ECROYD, FREDERICK THOMAS ..	Council Offices, Moss Side, Manchester.
B	1900 Mar. 27.	EDWARDS, ERNEST WILLIAM JOHN	Minas de San Albino, El Icaro, Nueva Segovia, Nicaragua.
	1900 Feb. 13.	EDWARDS, GERALD THORNHILL	Waterworks, Hayfield, Stockport.
	1900 Mar. 27.	EDWARDS, HENRY ARTHUR ROLLESTON	Pyenest, Halifax, Yorks.
	1902 Nov. 5.	EDWARDS, JOHN BASIL	4 Holland Park, W.
	1903 Mar. 17.	EDWARDS, LINDSAY ERNEST ..	R. and K. Ry., Bhamora P. O., Bareilly, India.
	1901 Nov. 19.	EDWARDS, RONALD WILLIAM.	96 Truro Rd., Wood Green, N.
	1899 Mar. 28.	ELDER, JOHN LOCKHART ..	17 Regent Street, Nottingham.
	1901 Dec. 17.	ELLERTON, ARTHUR STANTON	28 Parliament Hill, Hampstead, N.W.
	1900 Dec. 18.	ELLINGTON, NOEL BAYZAND ..	24 Warwick Street, Rugby.
	1903 Nov. 17.	ELLIOTT, STANLEY STEUART, B.A. (*Cape*)	Central Technical College, S. Kensington, S.W.
	1903 Mar. 17.	ELLIOTT - COOPER, MALCOLM, B.A. (*Cantab.*)	81 Lancaster Gate, W.
	1902 Nov. 11.	ELLIS, HENRY EDWARD THOMPSON	6 Edith Road, West Kensington, W.
	1900 Mar. 27.	ELLIS, HORACE WILLIAM ..	108 Wellgate, Rotherham.
	1904 Mar. 29.	ELLIS, JOHN	136 West Derby Road, Liverpool.
	1902 Nov. 5.	ELLIS, JOHN ATTWILL	49 Inderwick Road, Hornsey, N.
	1901 Feb. 12.	ELSDEN, FRANK VINCENT ..	38 St. Stephen's Gardens, St. Margaret's, Twickenham.
	1900 Nov. 27.	ENGLEHEART, PAUL, B.A. (*Cantab.*)	14 Gloucester Place, Greenwich, S.E.
	1903 Dec. 15.	ERLEBACH, WILFRID ARTHUR	Blencathara, Shepherd's Hill, Highgate, N.
	1902 Dec. 9.	ETHERIDGE, HERBERT OSBOURNE HAGGAR	P. W. & C. S. Meik, 16 Victoria Street, S.W.
	1899 Dec. 12.	EUGSTER, OSCAR	Barnsbury Works, Barnsbury St., N.
	1901 Nov. 19.	EVERARD, BERNARD, B.A. (*Cantab.*)	Woodville, Knighton Park Road, Leicester.

1901 Jan. 8.	FANE, ALMERIC CECIL	Bicester House, Bicester.
1900 Dec. 18.	FANE, ARTHUR GEORGE CECIL	Grindlay, Groom & Co., Bombay.
1901 Nov. 19.	FANSHAWE, JOCELYN HERBERT	Heathmere, Hayward's Heath.
1902 Jan. 21.	FARMER, FRANK HARVEY, B.Sc. (*Victoria*)	Green Fuel Economiser Co., 74 Cortlandt Street, New York, U.S.
1904 Mar. 29.	FARRANT, JAMES CLIFFORD ..	10 The Terrace, Woodford Green.
1899 Nov. 28.	FENNELL, JOHN HOWARD ..	Minas de Rio Tinto, Spain.
1902 Mar. 25.	FINCH, FRANK GEORGE	Boro' Engineer's Office, Reading.
1903 Dec. 15.	FINCH, WILFRED HENRY MONTGOMERY	28 Mulgrave Street, Princes Park, Liverpool.
1904 Mar. 29.	FINCHAM, EDGAR MOWBRAY ..	22 De Grey Road, Leeds.
1902 Nov. 5.	FIRMSTON, ERIC VERNON ..	39 Margaret St., Cavendish Sq., W.
1899 Nov. 28.	FIRTH, CHARLES TURNER ..	Prospect House, Idle, Bradford.
1902 Feb. 11.	FITT, EDWARD MCCARTHY ..	10 Edgecumbe Road, Redland, Bristol.
1900 Mar. 27.	FITZGIBBON, WILLIAM NOËL	Royal Survey Dept., Bangkok, Siam.
1897 Nov. 10.	FITZSIMONS, HERBERT WALTER, B.Sc. (*Lond.*)	J. J. Webster, 39 Victoria St., S.W.
1903 Nov. 24.	FLETCHER, BASIL PROCKTER..	4 Rectory Terrace, Gosforth-on-Tyne.
1898 Nov. 8.	FLETCHER, WALTER TOWNSHEND	The Chantry, Wimborne.

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Date of Admission.	STUDENTS.	
1899 Nov. 28.	FLINT, FRANK DEAN	The Moors, Bishopsteignton, Teig mouth.
1902 Nov. 5.	FLOWERDEW, SPENCER PELHAM	Major Hudson, Central Jail, Nai Allahabad, India.
1897 Nov. 10.	FOLKES, TUDOR DAVID	11 Edgar Street, Worcester.
1903 Nov. 24.	FORBES, CHARLES GODFREY ..	19 Norwood Street, Ashford, Kent
1902 Nov. 5.	FORD, ERNEST HOME	Beechdale House, Bloxwich.
1900 Nov. 27.	FORD, FRANK GODFREY GARLAND	Via y Obras, F. C. Oeste, Buen Aires.
1898 Dec. 6.	FORD, WALTER WILLIAM ..	Govt. Rys., Maritzburg, Natal.
1903 Mar. 31.	FORMAN, JAMES HILL	160 Hope Street, Glasgow.
1902 Mar. 25.	FORSTER, MAURICE NORMAN ..	L. & S. W. Ry. Loco. Works, Ni Elms, S.W.
1904 Jan. 26	FORTESCUE, CECIL LEWIS, B.A. (*Cantab.*)	71 Wolverhampton Road, Stafford.
1900 Nov. 27.	FOULIS, WILLIAM	2 Montgomerie Quadrant, Kelvi side, Glasgow.
1903 Mar. 31.	FOWLER, RICHARD SAMUEL GARDINER, B.A., B.A.I. (*Dubl.*)	6 Duncairn Terrace, Bray, c Wicklow.
1902 Nov. 11.	FOX, JOHN REGINALD	5 Cleveland Place West, Bath.
1903 Jan. 20.	FOX, WALTER ERNEST, B.E. (*Royal*)	Engineer's Office, L. & S.W. Ry Waterloo, S.E.
1904 Mar. 29.	FOXLEE, RICHARD WILLIAM ..	Engineer's Office, G.N.R., King Cross, N.
1902 Mar. 25.	FRANCIS, EDWARD TYRRELL DUNKIN	577 Stretford Road, Manchester.
1899 Nov. 28.	FRANCIS, RONALD JOSEPH ..	50 Coolhurst Road, Shepherd's Hil
1897 Dec. 7.	FRANK, HERBERT WILLIAM ..	[illegible]
1902 Dec. 2.	FRANK, THOMAS PEIRSON ..	12 Belmont Street, Huddersfield.
1903 Nov. 24.	FRASER, PETER LOGAN RAEBURN	23 Cathcart Road, S. Kensingto S.W.
1898 Dec. 6.	FREEMAN, RALPH	6 Woodberry Down, N.
1901 Dec. 3.	FUNNELL, HERBERT NICHOLAS	54 Aytoun Road, Stockwell, S.W.
1902 Nov. 25.	FURSE, CHARLES FRANCIS ..	Box 1055, Johannesburg, Transvaa
1902 Mar. 11.	FYNES-CLINTON, ROBERT ..	Brush Electrical Engineering Co., 15 Corporation Street, Birmingham.
1902 Nov. 5.	GALLINI, ALFRED MAURICE DOMINIC	Glencairn, Wimbledon, S.W.
1899 Nov. 28.	GARDNER, CHARLES TURVILLE	Railways, Box 333, Bulawayo, Rho desia.
1902 Mar. 25.	GARDNER, JOHN	9 Anerley Park, S.E.
1902 Jan. 28.	GARDNER, WILLIAM ERNEST ..	61 Pershore Road, Edgbaston.
1902 Dec. 2.	GARDOM, WILLIAM DOUGLAS CRONHELM	Bengal and N.W. Ry., Gorakhpu India.
1903 Nov. 17.	GARFORTH, THOMAS GEORGE ..	1 Albert Place, Chelsea, S.W.
1898 Nov. 22.	GARRIOCH, HENRY JOHN ..	76 Cobourg Street, Plymouth.
1902 Nov. 25.	GATEHOUSE, ERNEST ARTHUR	23 Garden Walk, Ashton, Preston.
1903 Nov. 24.	GATES, HARALD BURTON ..	Charnwood, Chapter Road, Willesd Green, N.W.
1904 Feb. 16.	GAUDIN, REGINALD FRANCIS BOYD	76 Philbeach Gardens, S.W.
1903 Feb. 17.	GAUNT, LOUIS HENRY ARMISTEAD	Sunfield Cottage, Stanningley, Leeds
1898 Dec. 6.	GAUVAIN, WILLIAM PERCIVAL	Hathorn, Davey & Co., Sun Foundry Leeds.
1903 Mar. 24.	GEEN, ALBERT BERNARD ..	Kingsthorpe, The Avenue, Su biton.
1903 Jan. 13.	GEEN, GEORGE PURDON	Ivor Villa, Newport, Mon.

Date of Admission.	STUDENTS.	
1902 Dec. 2.	George, Charles Herbert ..	Oakenclough, Limehurst, Ashton-under-Lyne.
1903 Nov. 10.	George, Maelgwyn Glendower, B.Sc. (*Wales*)	Maesyrhof, Clydach Vale, Rhondda.
1898 Nov. 22.	German, Bernard Foster ..	Gya-Katras Ry., Manpur, Gya, India.
1900 Dec. 18.	Ghaleb, Kamel Osman	Projects Circle, Minia, Egypt.
1899 Nov. 28.	Gibb, Andrew Shirra	P.W.D., Jhelum Canal, Rasul, Punjab.
1903 Nov. 10.	Gibbs, Charles William ..	Central Technical College, Exhibition Road, S.W.
1902 Mar. 18.	Gibson, Douglas Heugh ..	30 Richmond Mansions, Earl's Court, S.W.
1901 Nov. 19.	Gibson, Lawrence James Douglas, M.A., B.Sc. (*St. Andrews*)	Midland Ry., Horbury Bridge, Wakefield.
1899 Nov. 28.	Giles, Humphrey Noel, B.Sc. (*Victoria*)	6 Gambier Terrace, Liverpool.
1902 Feb. 4.	Gill, James Francis, B.Sc. (*Victoria*)	72 Strand Road, Bootle, Liverpool.
1903 Mar. 24.	Gill, John Richmond	10 Clareville Gardens, Hanwell, W.
1903 Mar. 24.	Gillett, Bernard George ..	Colyton, Leigham Court Road, Streatham, S.W.
1903 Nov. 24.	Gimson, Martin	White House, Clarendon Park, Leicester.
1899 Nov. 28.	Glanville, Ernest Alfred	Madras Ry., Rayapuram, Madras.
1904 Mar. 29.	Glasgow, Nesbit	The Châlet, Fulham Park Road, S.W.
1900 Mar. 26.	Goldson, John Wilgress ..	Banchory House, Beach Road, Portishead.
1899 Feb. 28.	Golla, Lucien Cater	
1902 Mar. 25.	Gooding, Thomas Oliver ..	Bentworth, Woolston, Southampton.
1903 Dec. 22.	Gosford, Albert Thomas ..	King's College, Strand, W.C.
1904 Mar. 22.	Gostwyck, Godfrey Harold Gostwyck	21 Delahay Street, Westminster, S.W.
1901 Mar. 26.	Grace, Lawrence Thornewaite	10 Smith Street, King's Road, Chelsea, S.W.
1901 Feb. 12.	Granger, John Maxwell ..	Govt. Rys., Ceres, Cape Colony.
1900 Mar. 6.	Grant, Ewan Maitland ..	Govt. Rys., Engineer's Office, Cape Town, C.C.
1904 Mar. 29.	Grant, Ian	Engineer's Office, N.E. Ry., York.
1903 Nov. 10.	Grant-Dalton, Alan Trevanion	Govt. Rys., Port Elizabeth, C.C.
1901 Jan. 8.	Green, Frederick Michael	40 Belsize Park, N.W.
1902 Jan. 28.	Greenwell, George Harold	Poynton, Cheshire.
1899 Nov. 28.	Greg, Lionel Hyde	Dowlaishweram, Godavari, Madras.
1904 Mar. 29.	Gregory, Herbert George ..	110A Southampton Row, W.C.
1902 Mar. 25.	Gregory, Reginald Victor ..	199 Anerley Road, Anerley, S.E.
1900 Nov. 27.	Gribble, Conrad	N.E. Ry., Engineer's Office, York.
1902 Nov. 5.	Griffin, Frederick Charles	39 South Street, Stourbridge.
1902 Nov. 11.	Griffin, Joseph Darius ..	Hanbury Hill House, Stourbridge.
1901 Nov. 27.	Griffiths, Harry Melville	King, King & Co., Bombay.
1902 Dec. 2.	Grigson, Thomas Reginald ..	118 Cathedral Road, Cardiff.
1901 Dec. 11.	Grinling, Arthur John ..	32 Friar Gate, Derby.
1903 Dec. 15.	Groves, Henry Leigh, B.A. (*Cantab.*)	69 Eaton Terrace, S.W.
1902 Dec. 2.	Gubbay, Henri	Royal Indian Engineering College, Staines.
1899 Nov. 28.	Guest, *Hon.* Lionel George William	Canford Manor, Wimborne.
1896 Nov. 16.	Guest, Robert	Old Castle, Kinnerley, Herefordshire.
1901 Nov. 27.	Gunson, Ernest	10 Victoria Avenue, Barrow-in-Furness.

Date of Admission.	STUDENTS.	
1902 Nov. 5.	GUTTMANN, CAMILLO JOSEPH	18 Aberdare Gardens, Hampstea N.W.
1903 Mar. 10.	GYTON, FREDERICK GEORGE ..	10 Highbury Crescent W., Hollow
1900 Feb. 27.	HADDIN, JOHN	4 Millbrae Crescent, Langsid Glasgow.
1899 Nov. 28.	HADOW, RAYMOND PATRICK ..	King, King & Co., Bombay.
1904 Mar. 29.	HALL, LIONEL CUTHBERT ..	New Dock Works, Southampton.
1902 Mar. 25.	HALLOWES, BLACKWOOD.. ..	11 King Street, Maidstone.
1901 Nov. 19.	HAMER, JOHN PARKINSON ..	Oakley, St. Andrew's Road, S Anne's-on-Sea.
1904 Feb. 9.	HAMILTON, BENJAMIN HENRY NOEL HANS	St. Kilda, Wimbledon, S.W.
1900 Mar. 27.	HAMPSON, HENRY ALGERNON	Lancaster House, Berea, Durba Natal.
1903 Nov. 10.	HANNINGTON, ROBERT GEORGE	117 Dean Street, Swindon.
1900 Nov. 27.	HANSON, HAROLD	Holmwood, Edgerton, Huddersfiel
1903 Mar. 24.	HARBY, WILLIAM	43 Montgomery Street, Edinburg
1901 Dec. 3.	HARDIE, JOHN ALFRED	Tighnaburn, Glasgow Road, Paisle
1904 Mar. 29.	HARDING, GEORGE RICHARDSON	Dick, Kerr & Co., Star Chambe Gosport.
1904 Mar. 29.	HARLEY-MASON, VERNON BALFOUR	34 Dulwich Road, Herne Hill, S.E
1902 Mar. 25.	HARMAN, FREDERICK BERKELEY BRUCE	15 Old Heath Road, Colchester.
1901 Dec. 3.	HARRIS, ALFRED RICHARD ..	272 Walthall Street, Crewe.
1903 Nov. 10.	HARRIS, ARNOLD WILLIAM ELSMERE	The Red House, Barnt Green, Bi mingham.
1900 Nov. 27.	HARRIS, CHARLES WILLIAM ..	Harbour Trust, Sydney, N.S.W.
1904 Mar. 15.	HARRIS, THOMAS HOWARD ..	28 Coniston Avenue, Jesmon Newcastle-on-Tyne.
1904 Jan. 26	HARRISON, ARNOLD FREAN, B.Sc. (*Victoria*)	St. Arnold's, Broad Oak Par Worsley.
1897 Nov. 10.	HARRISON, ERNEST YOUNG ..	Borough Surveyor's Office, Leiceste
1904 Mar. 29.	HARRISON, FRANCIS EDWARD..	3 Summerhill Terrace, Newcastle on-Tyne.
1903 Nov. 24.	HARRISON, NORMAN EDMOND	20 Derwent Road, Anerley, S.E.
1902 Nov. 5.	HART, VINCENT	Westmere, Western Road, Cork.
1903 Nov. 10.	HARTLEY, SIDNEY	Beechcroft, Ollerton, Knutsford.
1903 Dec. 22.	HASKINS, WILFRED JOSEPH ..	Warmley House, Warmley, Bristol
1901 Dec. 11.	HAWTHORNE, WILLIAM, B.A. (*Royal*)..	C. H. Merz, Collingwood Building Newcastle-on-Tyne.
1900 Nov. 27.	HAYES, ARTHUR EDWARD ..	"Mansefield," Stony Stratford.
1904 Mar. 29.	HAYMAN, WILLIAM MUIR ..	Engineer's Office, St. Enoch Statio Glasgow.
1903 Mar. 24.	HAYTHORNTHWAITE, ARNOLD THOMPSON	2 Vernon Gardens, Gateshead-on Tyne.
1902 Mar. 25.	HEAP, HUGH PERCY	New Dock Works, Southampton.
1903 Nov. 24.	HEATHCOTE, LAWRENCE HECTOR MARK	Royal Indian Engineering Colleg Staines.
1899 Mar. 28.	HEATHER, AUBREY GEORGE FORSTER	Sheba G. M. Co., Eureka, Barberton Transvaal.
1898 Nov. 8.	HEENAN, JOHN HAMMERSLEY	Harbour Works, Durban, Natal.
1903 Mar. 24.	HELLIWELL, HUBERT	13 Drummond Place, Edinburgh.
1903 Nov. 17.	HELSBY, FREDERICK GEORGE..	University College, Gower St., W.C
1903 Mar. 24.	HENDERSON, DAVID	26 Calder Street, Glasgow.
1899 Nov. 28.	HENRIQUES, CYRIL QUIXANO ..	16 Oxford Square, Hyde Park, W.
1897 Nov. 10.	HENRIQUES, EDWARD CECIL QUIXANO	81 Balliol Road, Bootle, Liverpool.
1900 Nov. 27.	HENRIQUES, FRANK CHARLES..	75 Oxford Gardens, North Kensin ton, W.

Date of Admission.	STUDENTS.	
1903 Nov. 24.	HENRY, WILLIAM	Engineer's Office, N.E. Ry., Newcastle-on-Tyne.
1902 Mar. 25.	HEPWORTH, WILLIAM	Lancs. & Yorks. Ry., Bolton.
1903 Mar. 24.	HESTER, EDGAR HAZEL	51 Upper Westbourne Villas, Hove.
1900 Feb. 13.	HEWLETT, PHILIP RUFFORD ..	166 Willesden Lane, Brondesbury, N.W.
1903 Dec. 15.	HEYMANN, FRANCIS ALBERT	Royal Indian Engineering College, Staines.
1899 Nov. 28.	HICKS, GEORGE AUGUSTUS ..	Agent's Office, Burma Railway, Rangoon, Burma.
1902 Nov. 5.	HIGHTON, DOUGLAS CLIFFORD, B.A. (*Cantab.*)	King's College, Cambridge.
1904 Jan. 26.	HILDITCH, GEORGE WALLS ..	Home Park, Kingston-on-Thames.
1903 Mar. 24.	HILL, FREDERICK GUY	Hillscroft, Erdington, Birmingham.
1902 Nov. 25.	HINGSTON, WILLIAM HALCOT	46 Dartmouth Rd., Forest Hill, S.E.
1902 Mar. 25.	HODGSON, HUBERT MERVYN TYLSTON	Harpenden, Herts.
1900 Nov. 27	HODGSON, JOSEPH POLLARD ..	H. Arnold & Son, New Reservoir, Hartshead Moor, Cleckheaton.
1902 Mar. 25.	HODGSON, REGINALD	8 Richmond Place, Brighton.
1902 Mar. 25.	HOGG, CHARLES WILLIAM ..	12 India Street, Glasgow.
1902 Jan. 21.	HOGG, JOHN MACKINTOSH ..	12 India Street, Glasgow.
1901 Mar. 26.	HOGG, WILLIAM EDWARD ..	7 Westover Road, Wandsworth, S.W.
1899 Nov. 28.	HOLDEN, HUON	Cwm Elan, Rhayader, Rads.
1897 Nov. 10.	HOLLIDAY, JAMES HARRY ..	St. Luke's Rectory, Miles Platting, Manchester.
1899 Jan. 17.	HOLMES, FRANCIS GREAME ..	Engineer's Office, L. & Y. Ry., Brighouse, Yorks.
1899 Nov. 28.	HOMER, ERNEST ERIC FERRIS	Godlingstone House, Swanage.
1903 Nov. 10.	HONE, HORACE JOHN ELLIOTT	62 Kensington Road, Reading.
1904 Feb. 9.	HOPE, RALPH JAMES, B.A.I. (*Dublin*)	The Vicarage, Drung, Cavan, Ireland.
1903 Jan. 13.	HORN, WILLIAM ROWATT ..	8 Thompson Street, Aberdeen.
1900 Dec. 18.	HORNE, GEORGE REMINGTON ..	Tremayne, Wynberg, Cape Colony.
1900 Dec. 18.	HORNE, WILLIAM NEVILL ..	Tremayne, Wynberg, Cape Colony.
1900 Mar. 6.	HOUNSFIELD, ARTHUR GERALD	Les Moulins, Sèvres, France.
1901 Nov. 19.	HOYLE, EDGAR	Cliff House, Greenhithe, Kent.
1902 Nov. 5.	HUBBACK, GEORGE CLAY, B.Sc. (*Victoria*)	247 Folkestone Road, Dover.
1899 Jan. 10.	HUDDART, LINDOW HEREWARD LEOFRIC, B.A. (*Cantab.*) ..	2 Chatsworth Gardens, South Cliff, Eastbourne.
1902 Nov. 25.	HUGHES, IAN DAVID ERSKINE	Royal Indian Engineering College, Staines.
1904 Feb. 16.	HUGHES, WILLIAM CLARE ..	H. Birkett, 197 Edgware Road, W.
1903 Mar. 24.	HUGHES, WILLIAM OSBORNE ..	Cartref, Cadnant Park, Conway.
1904 Mar 29.	HULL, GORDON BURNETT GIFFORD	Hayfield, Derbyshire.
1901 Mar. 26.	HUMAN, ARNOLD HENRY ..	Siemens Brothers, Stafford.
1900 Nov. 27.	HUMFREY, JOHN CHARLES WILLIS, B.Sc. (*Victoria*) ..	Wilden, near Stourport.
1901 Nov. 27.	HUNT, GEORGE EDWARD ..	217 West George Street, Glasgow.
1899 Jan. 31.	HUNTER, JOHN INGLIS	1 Albany Terrace, Windsor.
1903 Nov. 10.	HUNTER, THOMAS MACMILLAN, M.A., B.Sc. (*Glasgow*) ..	31 Lynedoch Street, Glasgow.
1900 Nov. 27.	HUSBANDS, HENRY WILLIAM SPURR	E. Nuttall & Co., 5 Piccadilly, Walcot, Bath.
1904 Mar. 29.	HUTCHINSON, HARRY FLEMING	2 Queen's Road, Chorley.
1903 Nov. 10.	HUTCHINSON, JAMES ANNACKER	Rawcroft, Combe Park, Bath.
1904 Mar. 29.	HUTCHISON, DONALD MAXWELL WRIGHT	19 Milton Street, Maidstone.
1898 Nov. 22.	HUTTON, CHARLES INGLIS ..	Railway Co., Insein, Burma.
1898 Dec. 13.	HUTTON, WILLIAM AUSTIN ..	East Indian Ry., Asansol, India.
1901 Mar. 26.	HUXHAM, WILLIAM HENRY ..	91 Salisbury Road, Plymouth.

Date of Admission.	STUDENTS.	
1902 Mar. 18.	IMBER, ARTHUR HENRY ..	Ivydene, Albany Road, Hersh Walton-on-Thames.
1903 Apr. 28.	INGLIS, ROBERT JOHN MATHISON	Tantah, Peebles.
1902 Nov. 11.	INNES, CHARLES, B.Sc. (*Edin.*)	Kyle, Dennison & Laing, 13 Geo Street, Edinburgh.
1902 Nov. 18.	IRANI, RUSTOMJI HORMUSJI, F.C.H.	3 Main Street, Poona, India.
1902 Mar. 11.	ISLE, WILLIAM COLLINSON, B.Sc. (*Victoria*)	Boston Road, Horncastle, Lincs.
1899 Nov. 28.	ISAT, JOHN	E. B. S. Ry., Krishnagar, India.
1899 Nov. 28.	JACKSON, EDWARD ROBERT HOULTON	Port Trust, Bombay.
1903 Nov. 24.	JACOB, LIONEL HERBERT ..	Glenelg, Westbourne Park Ro Bournemouth.
1900 Dec. 18.	JAY, WILLIAM CLOUSTON ..	Greymouth, N.Z.
1898 Dec. 20.	JENKIN, IVOR WILFRID	56 Gauden Road, Clapham, S.W.
1901 Nov. 19.	JENKINS, WILLIAM LIONEL ..	Wadham House, Toynbee H Commercial Street, E.
1902 Dec. 16.	JENKINS, WILLIAM REES ..	Town Hall, Burton-on-Trent.
1901 Dec. 3.	JENNINGS, FRANK PERCY ..	Reddeholm, Duffield Road, Derb
1900 Mar. 27.	JOHNSON, HARRY OSCAR	1226 7th Avenue, Altoona, Pa., U
1903 Dec. 22.	JOHNSTON, JOHN CORMACK ..	3 Moray Street, Wick, N.B.
1898 Nov. 8.	JONES, ADRIAN BROOKHOLDING	David Simson, Casilla de Cor 741, F. C. Oeste, Buenos Aires
1899 Nov. 28.	JONES, CYRIL WALTER	3 White Hart Lane, Wood Green,
1898 Nov. 22.	JONES, GERALD LLOYD	City of London Electric Lighti Co., Bankside, S.E.
1903 Nov. 10.	JONES, GWILYM ANEURIN ..	6 Montpelier Terrace, Swansea.
m ✠ 1897 Mar. 29.	JONES, HARRY OSCAR	Boro' Engineer's Office, Folkesto
1899 Mar. 28.	JONES, JOHN FREDERICK ..	Suspension Bridge, Conway.
1903 Dec. 22.	JOSEPH, JACOB BENJAMIN ..	Prof. Henry Robinson, Parliam Mansions, Victoria Street, S.W.
1903 Nov. 10.	KATIGBAK, JOSÉ PETRONIO ..	Smith, Wood and Co., 3 and Lime Street Square, E.C.
1904 Mar. 29.	KEAST, SYDNEY BANKS	28 Victoria Street, S.W.
1904 Mar. 29.	KEAY, CUTHBERT MACLAREN	Beach House, King Street, Broug Ferry, N.B.
1904 Mar. 29.	KEITH, WILLIAM EWING ..	Wood View, Beeston, Leeds.
1898 Jan. 18.	KENNEDY, JOHN MCFARLANE.	1 Queen Anne Street, W.
1899 Nov. 28.	KENNEDY, WILLIAM HENRY ..	W. Watson & Co., Bombay.
1903 Nov. 24.	KENT, CLAUDE GEORGE	Walter Beesley, 11 Victoria Str S.W.
1901 Dec. 11.	KESTING, ROBINSON FRIEDRICH	Lynwood Grange, Heaton Ro Newcastle-on-Tyne.
1899 Mar. 21.	KIBBLE, EDMUND DAVID ..	52 West Cromwell Road, S.W.
1902 Feb. 4.	KIERNAN, THOMAS JOHN RANSOM	21 Fawnbrake Avenue, Herne S.E.
1897 Feb. 16.	KILLICK, JOHN SPENCER ..	Barming, Maidstone.
1903 Dec. 22.	KING, JOSEPH STUART	Town Hall, Wolverhampton.
1903 Apr. 7.	KING, NORMAN ARTHUR	5 Hargreaves Road, Sefton Liverpool.
1903 Jan. 20.	KINGSBURY, PERCY CHARLES ..	26 Tachbrook Street, Pimlico.
1900 Nov. 27.	KIRBY, FREDERICK OSCAR ..	39 Waterdale, Doncaster.
[illegible] 17.	KIRKLAND, THOMAS JAMES ..	90 Carleton Rd., Tufnell Park,

Date of Admission.	STUDENTS.	
1903 Nov. 10.	KNIGHT, WALTER DINGLE ..	Darley, Cottenham Park, Wimbledon, S.W.
1899 Nov. 28.	KNOWLES, GUY JOHN FENTON	Park Lodge, Albert Gate, S.W.
1903 Mar. 24.	KOLLBRUNNER, HANS FRED ..	Umgeni Engine Works, Durban, Natal.
1901 Dec. 17.	KRETSER, HERBERT KENNETH DE	Mrs. Fleming, 69 West End Park Street, Glasgow.
1903 Nov. 10.	LACE, ERNEST WILLIAM	St. Leonard's, Ryde, I.W.
1903 Nov. 24.	LACEY, ONWARD BAYES	265 Walthall Street, Crewe.
1904 Feb. 16.	LACEY, STEPHEN	Bridge House, Bromley-by-Bow, E.
1902 Jan. 21.	LAING, JAMES NIVEN, B.Sc. (*Victoria*)	Berry's View, Queen's Park, Manchester.
1897 Nov. 10.	LAKE, WALLACE STICKLAND ..	2 Marlborough Road, Plymouth.
1903 Nov. 24.	LAMBERT, LESLIE CARLTON ..	42 Breakspears Road, Brockley, S.E.
1903 Mar. 10.	LANCASTER, GILBERT COLLIER	3 Bloomfield Terrace, Upper Wells Road, Bath.
1899 Mar. 21.	LANDON, CYRIL	King, Hamilton & Co., Calcutta.
1900 Nov. 27.	LANDON, JOSEPH WHITTINGTON	Sidney Sussex College, Cambridge.
1902 Nov. 5.	LANE, CHARLES MACDONALD	P. W. D., Sukkur, Sind, India.
1901 Mar. 12.	LANGTON, AUBREY RICHARD ..	13 Calverley Park, Tunbridge Wells.
1901 Nov. 19.	LAPAGE, JOHN NORMAN ..	35 Bromley Road, Beckenham.
1903 Nov. 10.	LATHAM, ERNEST, Jun.	234 Portsdown Road, Maida Vale, W.
1900 Mar. 27.	LAWRANCE, FREDERICK	29 Prince of Wales' Road, Battersea Park, S.W.
1901 Nov. 19.	LAWSON, FRANCIS MALCOLM ..	Northside, Leigh Woods, Bristol.
1901 Mar. 26.	LAWSON, WILLIAM	6 Akenside Terrace, Newcastle-on-Tyne.
1899 Nov. 28.	LAWTON, HAROLD	98 High Street, Poole.
1899 Jan. 10.	LEA, DONALD HENRY	1 Laurence St., Partick, Glasgow.
1904 Mar. 22.	LE CLERCQ, ALFRED GEORGE	10 Victoria Street, S.W.
1903 Nov. 10.	LECLEZIO, ALFRED JEAN ALEXIS	Port Louis, Mauritius.
1901 Dec. 11.	LEE, HAYDN	St. Aubyns, Morris Lane, Kirkstall, Leeds.
1900 Jan. 30.	LEE, WALTER	38 Worple Road, Wimbledon, S.W.
1900 Nov. 27.	LEEPER, LEONARD	Boro' Surveyor's Office, Great Yarmouth.
1902 Nov. 5.	LEES, GEOFFREY	c.o. Mrs. Burch, 16 Stanley Crescent, Kensington Park Gardens, W.
1904 Mar. 29.	LEES, THOMAS, Junr.	King's Arms Hotel, Girvan, Ayrshire.
1898 Nov. 8.	LEGGE, FRANCIS AUGUSTUS ..	Southwark and Vauxhall Water Co., Southwark Bridge Road, S.E.
1898 Mar. 29.	LEGGE, RONALD GEORGE ..	
1900 Nov. 27.	LEIGHTON, ARTHUR	7 Oxford Road, Birkdale, Lancs.
1902 Nov. 5.	LEITCH, PATRICK ARTHUR ..	15 Ardgowan Square, Greenock.
1903 Mar. 24.	LESLIE, JAMES	5 Douglas Gardens, Edinburgh.
1898 Dec. 6.	LESTER, LLEWELLYN ROLLS ..	32 Derby Street, Moss Lane East, Manchester.
1902 Dec. 2.	LEWIN, HERBERT WILLIAM ..	67 Trumpington Street, Cambridge.
1903 Nov. 24.	LEWIS, WILLIAM PHILLIP ..	Abercanaid, Merthyr Tydfil.
1903 Mar. 31.	LEYLAND, JOHN DUNCAN FRANCIS	Crimsworth Dene, Perry Vale, Forest Hill, S.E.
1903 Mar. 24.	LIGHTFOOT, KENNETH	Yorkshire College, Leeds.
1901 Nov. 19.	LINDLEY, EDWARD SEARLES, B.A. (*Cantab.*)	Godstone Place, Godstone, Surrey.
1904 Mar. 29.	LINDLEY, FRANCIS EMIL SEARLES	153 Finborough Road, S.W.
1902 Dec. 2.	LINNELL, CHRISTOPHER HENRY	Duddon Lodge, Tarporley, Cheshire.
1898 Dec. 13.	LINSKILL, WILLIAM ARTHUR	9 Canada Dock, Liverpool.

	Date of Admission.	STUDENTS.	
	1901 Mar. 26.	LISTER, JOHN EDWARD	5 Priory Place, Sharrow, Sheffield.
M f ✠	1901 Apr. 16.	LLOYD, HERBERT FETHERSTON	Coleshill Lodge, Sutton Coldfield.
	1904 Mar. 29.	LLOYD, WILLIAM EDWARD ..	38 Recreation Road, Stoke, Guildford
	1903 Mar. 24.	LOCKHART, WILLIAM DOUGLAS	42 Pembroke Road, Kensington, W
	1900 Nov. 27.	LOGGIN, GEORGE NICHOLAS ..	Harbour Works, Gibraltar.
	1901 Dec. 11.	LOMAS, KENNETH THURSTON	St. Jean, Territet, Switzerland.
	1903 Nov. 24.	LOVEGROVE, EDWIN GUY LIDSTONE	Engineer's Dept., G.N.R., King Cross, N.
	1903 Nov. 24.	LOWSLEY, CONRAD OFFA ..	Royal Indian Engineering College Staines.
	1900 Mar. 27.	LOWSLEY, SYDNEY EVAN ..	Municipal Offices, Harrogate.
	1900 Mar. 27.	LUKE, RICHARD CHARLES MONTAGUE	23 Seaton Avenue, Mutley, Plymouth
	1900 Nov. 27.	LUNDIE, CORNELIUS RONALD ..	136 Newport Road, Cardiff.
	1901 Nov. 19.	LYONS, NICHOLAS DANIEL ..	Boro' Engineer's Office, Dover.
	1903 Nov. 24.	MAAS, NORMAN NATHAN ..	78 Fellows Road, N.W.
	1904 Jan. 12	MCBRETNEY, WALTER, B.Sc. (*Lond.*)	Corporation Electricity Works, Ipswich.
	1897 Dec. 21.	MACCALL, WILLIAM TOLMÉ ..	St. Olave's, Hesketh Park, Southport.
	1900 Dec. 18.	MCCALLUM, ROBERT TOWSON	Midland Railway, Crigglestone Wakefield.
	1902 Feb. 11.	MCCLURE, ANDREW, B.A. (*Oxon.*)	Bamford, Sheffield, Derbyshire.
	1903 Jan. 20.	MCCOMAS, HAROLD, B.A.I. (*Dubl.*)	c.o. H. S. King & Co., Pall Mall, S.W
	1903 Dec. 22.	MCCRAE, ARTHUR GORDON, B.E. (*Sydney*)	34 Bernard Street, Russell Square W.C.
	1899 Nov. 28.	MCCRAITH, BERNARD	P.W.D., Rajputana, India.
	1904 Mar. 29.	MACCULLOCH, WILLIAM STEVENSON	1 Octavia Terrace, Greenock, N.B.
	1897 Dec. 7.	MACDERMOTT, OWEN LEONARD	17 Dalesbury Road, Upper Tooting S.W.
	1903 Mar. 24.	MACDONALD, STUART MAGNUS	41 Hook Road, Epsom.
	1898 Nov. 22.	MCDONALD, THOMAS JAMES ..	G.N. & Strand Ry., 292 Pentonville Road, N.
	1899 Nov. 28.	MACKAY, JOHN MITCHELL ..	Public Offices, Barking, Essex.
	1902 Mar. 25.	MACKENZIE, ALLAN CAMPBELL	Engineer's Office, Canadian Pacific Ry., Montreal, Canada.
	1899 Nov. 28.	MACKENZIE, COLIN CHARLES FORBES	Govt. Rys., Wadi Halfa, Sudan.
	1899 Nov. 28.	MCKENZIE, KENNETH EDWARD	Byculla Saw Mills, Mazagon, Bombay.
	1903 Mar. 24.	MACKIE, RONALD HASTINGS ..	47 Powerscroft Road, Clapton.
	1903 Nov. 24.	MCLAY, DAVID BIRD	Rose Lea, Uddingston.
	1900 Dec. 18.	MACLENNAN, FREDERICK JAMES	The Oaks, West End, Chobham, Surrey.
	1898 Nov. 22.	MACLEOD, HUGH TORQUIL ..	Madras Ry., Madras.
	1901 Apr. 16.	MCMURDO, ARCHIBALD HUGH	1 Annette St., Crosshill, Glasgow.
	1903 Nov. 24.	MACNAB, ALASTAIR MARCELL	Royal Indian Engineering College, Staines.
	1903 Nov. 24.	MADAPA, APPARANDRA BOPANNA	Royal Indian Engineering College, Staines.
	1903 Nov. 24.	MADDOX, FRANCIS JOSEPH WILLIAM	231 Westcombe Hill, Blackheath, S.E.
	1903 Nov. 10.	MALTHUS, ROBERT, B.A. (*Cantab.*)	Dalton Hill, Albury, Guildford.
	1899 Nov. 28.	MANN, ERNEST EDWIN, B.Sc. (*Victoria*)	Boro' Engineer's Office, Southampton.

Date of Admission.	STUDENTS.	
1900 Nov. 27.	Mann, Thomas Howells ..	25 Lexham Gardens, Kensington, W.
1903 Nov. 10.	Manson, Frederick Percy ..	Bengal N.W. Ry., Gorakhpur, India.
1899 Nov. 28.	Margaby, Thomas Louis ..	Eastern Bengal State Ry., Calcutta.
1902 Mar. 18.	Marlow, William John .	Malvern, Burton Road, Kingston-on-Thames.
1899 Nov. 28.	Marriott, Edward Guy ..	M. & G.N. Rys., Melton Constable.
1903 Jan. 27.	Marsh, Harry Evelyn	Broom Grove House, Sheffield.
1903 Nov. 24.	Marsland, Harold	Royal Indian Engineering College, Staines.
1904 Mar. 29.	Martin, Alick Gregory ..	R. E. W. Berrington, Lichfield Street, Wolverhampton.
1899 Nov. 28.	Martin, Henry Thorpe ..	Caledonian Ry., 3 Germiston Street, Glasgow.
1899 Nov. 28.	Martin, Oswald Stuart ..	Mirpur Khas, Thar & Parker, Sind, India.
1899 Dec. 5.	Martin, Richard Habington	S. I. Ry., Trichinopoly, India.
1902 Dec. 9.	Mason, Arnold Stewart ..	Waterworks Dept., Liverpool.
1901 Mar. 26.	Mathew, Harold Bertram ..	Borough Engineer's Office, Dover.
1903 Feb. 3.	Mathews, Ernest Gordon Dewar	Electric Station, Stuart Street, Manchester.
1903 Nov. 24.	Matthew, Frank Henry ..	12 Windermere Street, Gateshead.
1898 Nov. 8.	Matthews, Thomas Leigh ..	Admiralty Harbour Works, Dover.
1903 Mar. 24.	Matzinger, Edward Andrew	73 Arbuthnot Road, New Cross, S.E.
1903 Mar. 17.	May, Awdry John	Lyneham, Willow Grove, Chislehurst.
1902 Mar. 25.	Mayhew, Ernest Ford Watson	County Surveyor's Office, Brecon.
1902 Nov. 25.	Maynard, Farnham Edward	Overton, Babington Road, Streatham, S.W.
1902 Mar. 25.	Mead, John Robert	Stapenhill, Burton-on-Trent.
1899 Nov. 28.	Meaden, Bertram Grant ..	47 Breedon Hill Road, Derby.
1897 Apr. 6.	Mercer, Laurence Lestock	Railway Office, Waterport Wharf, Gibraltar.
1903 Mar. 24.	Messent, Edwin Josiah ..	Boro' Engineer's Office, Southend.
1902 Nov 5.	Metcalfe, Henry Ernest ..	30 Palmerston Buildings, Auckland, N.Z.
1902 Mar. 25.	Meyrick, Frederick Charles	Shire Hall, Nottingham.
1901 Dec. 11.	Michael, Richard Edward ..	Brook House, Tylorstown, Glam.
1901 Nov. 19.	Middleton, Cyril	City Engineer's Office, Newcastle-on-Tyne.
1900 Mar. 27.	Middleton, Harry	City Engineer's Office, Newcastle-on-Tyne.
1899 Nov. 28.	Middleton, James Hutton Tabor	Khanke, Punjab.
1902 Nov. 5.	Middleton, Reginald Fairfax	90 Kensington Park Road, W.
1901 Dec. 11.	Mileham, Christopher John	12 Albert Rd., Regent's Park, N.W.
1901 Nov. 19.	Miller, Hugh Alexander ..	24 Eldon Road, Kensington, W.
1902 Mar. 11.	Milliken, Robert Cecil ..	75 Murray Road, Rugby.
1903 Dec. 22.	Millington, William Ernest Wyatt	91 Bath Street, Rugby.
1899 Nov 28.	Milner, James Dalton ..	Town Hall, Hull.
1897 Nov. 23.	Minnitt, Henry William ..	Thames Civil Engineering Works, Dockyard, Gibraltar.
1900 Apr. 10.	Minors, Ernest	City Engineer's Office, Worcester.
1900 Nov. 27.	Mitchell, Alexander Cameron, Jun.	Weston House, Halewood, near Liverpool.
1901 Dec. 11.	Moberly, Charles Noel ..	Cottesmore, Tuddenham Rd., Ipswich.
1901 Nov. 19.	Monk, Reuben George	195 Junction Rd., Upper Holloway, N.
1900 Nov. 27.	Monro, Kenneth Neal, B.A. (*Cantab*)	Culross, Fifeshire, N.B.
1899 Nov. 28.	Montague, John Edward ..	Leigh Woods, Clifton, Bristol.
1903 Feb. 17.	Moore, Douglas Owen Milner	61 Hill St., Springburn, Glasgow.
1900 Mar. 27.	Moraes, Enrico José Pereira de	c.o. Pinto Leite & Nephew, 45 Moorgate Street, E.C.

Date of Admission.	STUDENTS.	
1903 Feb. 17.	MORAN, HENRY	65 Harrington Gardens, S. Kensington, S.W.
1899 Nov. 28.	MORGAN, JOHN DAVID	30 Whitehall Road, Handsworth Staffs.
1902 Mar. 25.	MORGAN, SYDNEY HUBERT ..	Boro' Engineer's Office, Middlesbrough.
1902 Mar. 25.	MORRIS, RICHARD VIVIAN ..	c.o. W. Morris, Kent Waterworks Deptford, S.E.
1899 Nov. 28.	MORRISON, ROBERT HENRY ..	Mondello Lodge, Eastbourne.
1903 Nov. 10.	MORSE, LEOPOLD GEORGE ESMOND	14 Airlie Gardens, W.
1903 Nov. 24.	MORT, HAROLD SUTCLIFFE, B.Sc. (*Sydney*)	Ocean Street, Woollahra, Sydney N.S.W.
1903 Jan. 13.	MOSER, FREDERICK WALCOTT FRANKLAND	Broadley, Sway, Hants.
1899 Dec. 12.	MOSS, RICHARD CECIL	St. Aubyns, Ballybrack, co. Dublin.
1899 Feb. 14.	MOSTYN, ROBERT VIVIAN WILKINSON	Rothay House, Peak Hill, Sydenham, S.E.
1898 Jan. 18.	MOTT, SYDNEY FRANK	Westmoreland Lodge, Wisteria Road, Lewisham, S.E.
1900 Dec. 18.	MOUNT, ALAN HENRY LAURENCE	Brompton Barracks, Chatham.
1904 Mar. 29.	MUDD, ARTHUR	1 Paley Road, Bradford.
1904 Mar. 22.	MUIRHEAD, THOMAS	Cloverhill, Knightswood, Glasgow.
1902 Nov. 5.	MUNRO, ROBERT CLARKE ..	16 Holford Square, W.C.
1902 Apr. 22.	MURPHY, JOHN JOSEPH	Watercourse Mill Road, Cork.
1902 Jan. 28.	MURRAY, RONALD CHARLES SCOTT, B.A. (*Cantab.*) ..	7 The Sanctuary, Westminster, S.W.
1902 Mar. 25.	MURRAY, WALTER	Midland Ry., Engineer's Office, Derby.
1901 Dec. 11.	MYERS, GEORGE DOUGLAS ALFRED	214 Camberwell Grove, S.E.
1901 Dec. 3.	NAPIER, ARTHUR GEORGE FRITZ, B.Sc. (*Victoria*)	Begari Canals, Jacobobad, Sind, India.
1902 Nov. 5.	NAPPER, WILLIAM ERNEST ..	B. & N. W. Ry., Gorakhpur, N.W.P., India.
1903 Mar. 24.	NASH, THOMAS STANLEY ..	78 Wrottesley Road, Plumstead.
1903 Dec. 15.	NEILSON, JAMES	Royal Indian Engineering College, Staines.
1904 Mar. 29.	NEILSON, ROBERT	6 Camphill Drive, Crosshill, Glasgow.
1902 Mar. 25.	NETTELTON, OSCAR TRAVES ..	Borough Engineer's Office, Town Hall, Reading.
1902 Nov. 5.	NEWLANDS, JOHN ERIC	27 Great King Street, Edinburgh.
1903 Nov. 24.	NEWTON, HAROLD ALEXANDER	13 Earl's Terrace, Kensington, W.
1902 Feb. 4.	NEWTON - CLARE, EDWARD THOMAS..	The Ferns, Beckenham, Kent.
1903 Dec. 22.	NICHOLSON, HARRY LECHLER, B.Sc. (*Lond.*)	Royal Indian Engineering College, Staines.
1902 Nov. 5.	NICHOLSON, HORACE WATSON, B.Sc. (*Lond.*)	Works Dept., H.M. Dockyard, Haulbowline, co. Cork.
1903 Nov. 10.	NICHOLSON, JOHN HEDLEY ..	21 Park Terrace, Consett, co. Durham.
1900 Nov. 27.	NISBET, WALTER SELWYN ..	The Old House, Wimbledon.
1901 Mar. 26.	NIVEN, ERNEST CUMMING ..	Port Engineer's Office, Rangoon, Burma.
1902 Nov. 5.	NIXON, ALEXANDER KENNEDY	6 St. George's Chambers, Cape Town, C.C.
1904 Mar. 29.	NOBLE, PETER..	Thames Ironworks, Tidal Basin, E.
1899 Mar. 21.	NORMAN, FRANK	The Pines, Epsom.

Date of Admission.	STUDENTS.	
1900 Feb. 13.	NORRIE, CHARLES MATTHEW, B.Sc. (*St. Andrews*)	Camphill House, Broughty Ferry, N.B.
1900 Nov. 27.	NORSWORTHY, HERBERT HENRY	30 Uplands Terrace, Swansea.
1903 Nov. 24.	NORTHCOTE, EDWARD STAFFORD	71 Dublin Road, Belfast.
1899 Nov. 28.	NORTHCOTE, HENRY FELIX ..	Niagara, Elsee Road, Rugby.
1899 Feb. 7.	NUNES, LIONEL GEORGE	P.W.D., Thaton Station, Lower Burma.
1903 Nov. 24.	OAKDEN, EDWARD	984 Prospect Street, Cleveland, Ohio, U.S.
1902 Nov. 25.	O'BRIEN, JOSEPH ANDREW ..	Selby House, Weighton Road Anerley, S.E.
1902 Jan. 28.	OGSTON, HAMISH NORMAN ..	Coundon Villa, Coundon Road, Coventry.
1903 Dec. 22.	OKELL, ALFRED WILLIAM, B.A. (*Cantab.*)	13 St. Aubyn's Road, Upper Norwood, S.E.
1903 Nov. 24.	OLDFIELD, ALF	Borough Engineer's Office, Batley.
1898 Nov. 8.	OMMANNEY, GEOFFREY GREAM	10 Prince of Wales Terrace, Kensington, W.
1903 Nov. 24.	ONSLOW, GUY CLEVLAND ..	Innerwyke Manor, Felpham, Bognor.
1901 Dec. 3.	ORME-WEBB, JAMES RODNEY..	Assam Rys. & Trading Co., Dibrugarh, Assam.
1902 Jan. 21.	ORMISTON-CHANT, THOMAS CLEMENT	Albemarle House, East Twickenham.
1904 Mar. 29.	ORRINSMITH, ROBERT EDWARD HARVEY	Sunny Bank, Christchurch Road, Hampstead, N.W.
1903 Dec. 22.	OSBORNE, ALEC FERGUSON ..	Spondon, near Derby.
1901 Dec. 11.	OSMOND, HAROLD	Laurel Farm, Totteridge.
1903 Dec. 15.	OSTLER, GEORGE ARTHUR ..	Murrayville, Stafford Road, Bournemouth.
1901 Nov. 19.	O'SULLIVAN, JOHN	Irrigation Dept., Alexandria, Egypt.
1903 Dec. 15.	O'SULLIVAN, VINCENT	Royal Indian Engineering College, Staines.
1898 Feb. 1.	OTWAY, JAMES HASTINGS ..	20 Northbrook Road, Dublin.
1901 Nov. 19.	OTWAY, PERCY MACEWAN ..	Sinnott & Stracey, Western Mail Chambers, Cardiff.
1903 Mar. 24.	OWEN, HENRY ATKINSON ..	City Engineer's Office, Leeds.
1904 Mar. 29.	PAIN, CLAUDE	A. C. Pain, 17 Victoria Street, S.W.
1901 Dec. 17.	PAIN, EDWARD DAVY, B.A. (*Cantab.*)	17 Victoria Street, S.W.
1903 Nov. 24.	PARKER, GEOFFREY	Royal Indian Engineering College, Staines.
1903 Mar. 24.	PARKER, HENRY EDMUND ..	c.o. R. E. Middleton, 17 Victoria St., S.W.
1903 Jan. 27.	PARKER, OWEN FOSTRIC, B.A. (*Cantab.*)	20 Marlborough Place, N.W.
1898 Nov. 22.	PARKER, WILLIAM ALEXANDER	Clyde Navigation, 16 Robertson Street, Glasgow.
1898 Nov. 8.	PARKINSON, PAUL GERHARDT	Carleton House, Hillfield Avenue, Hornsey, N.
1903 Nov. 10.	PARMITER, EUSTACE RAYNE ..	Ruddington, Nottingham.
1902 Nov. 5.	PARSONS, EDGAR ARTHUR ALICK	Compania de Luz de Cordoba, Cordoba, Argentina.
1903 Mar. 24.	PATERSON, ALEXANDER McCULLOCH	West Point, Shipley, Yorks.
1898 Nov. 22.	PATERSON, CLIFFORD COPLAND	National Physical Laboratory, Teddington.

	Date of Admission.	STUDENTS.	
	1904 Mar. 29.	Paterson, George Stuart ..	West Point, Shipley, Yorks.
	1901 Dec. 11.	Patterson, Francis Tucker.	Y.M.C.A., Cape Town Buildings South Africa.
	1904 Mar. 29.	Patterson, Joseph Albert ..	Trevor, Tilford Road, Farnham Surrey.
	1904 Mar. 29.	Pawley, Frank Lucoott ..	Quarry Bank, Hessle, East Yorks.
	1901 Mar. 26.	Paxton, Charles Henry ..	Contractor's Office, The Broadway Salford.
	1901 Nov. 19.	Payne, Lawrence Temple ..	8 Chiswell Street, E.C.
m	1899 Mar. 28.	Peach, Fleetwood Keighly	Platt House, Borough Green, Kent.
	1899 Nov. 28.	Pearce, Nathaniel	Aughton, near Ormskirk.
	1900 Mar. 27.	Pearson, Charles Dearne ..	Station Road, Amersham, Bucks.
	1900 Mar. 27.	Peat, James Barclay	Wykeham Rise, Totteridge, Herts.
	1899 Mar. 28.	Peel, Reginald	Fort Jameson, Rhodesia.
	1900 Nov. 27.	Pennell, Reginald Humphrey Lee	Admiralty Harbour Works, Dover.
	1902 Dec. 2.	Penney, John Ernest	47 Rossett Road, Crosby, Liverpool.
	1903 Dec. 15.	Pepperoorn, Geoffrey Arthur	5 The Paddock, Dover.
	1903 Dec. 22.	Peters, Reginald	Central Technical College, Exhibition Road, S.W.
	1899 Nov. 28.	Pethick, George Harold ..	Harbour Engineer's Office, Swansea.
	1902 Feb. 4.	Peyrecave, Louis François de Peyrecave	20 St. Leonard's Road, Ealing, W.
	1898 Mar. 15.	Phillips, Arthur Ernest ..	Torrington House, St. Albans.
	1899 Mar. 28.	Phillips, Edward Douglas ..	18 Prospect Road, St. Albans.
	1897 Nov. 23.	Phipps, Neville Leckonby ..	G. W. Ry., Gerrard's Cross, Bucks.
	1901 Mar. 26.	Pickles, Frank Atkinson ..	The Hirst, Saltaire, Shipley, Yorks.
	1902 Nov. 5.	Pierrepont, Gervas Evelyn	Higham Grange, Nuneaton.
	1903 Mar. 24.	Pike, Eustace Royston Baum	Island House, Loughborough.
	1902 Mar. 25.	Pink, Edward Sidney	5 Gwendolen Avenue, Putney, S.W.
	1904 Jan. 12.	Pink, Harold William ..	Cutherington, Hillborough Crescent, Southsea.
	1903 Nov. 24.	Pipe, Thomas Sylvanus ..	St. Saviour's Road, Saltley, Birmingham.
	1903 Mar. 31.	Pitcairn, William Erskine	28 Cluny Gardens, Edinburgh.
	1903 Mar. 10.	Pitt, Philip Septimus	Trinity College, Cambridge.
	1901 Nov. 19.	Plante, Stanley Gedge ..	5 Harsnett, Colchester.
	1902 Nov. 11.	Platt, Wilfred	Morredge, Manchester Road, Rochdale.
	1898 Nov. 22.	Plumpton, John Dudley ..	Cotswold, Glamorgan Road, Hampton Wick.
	1903 Nov. 24.	Pollard, Armell Richard, B.A. (*Cantab.*)	21 Ravensbourne Gardens, Ealing, W.
	1901 Dec. 11.	Pool, Harold..	10 Jasper Street, Hanley, Staffs.
	1902 Nov. 5.	Pooley, Charles Blois ..	Tapti Valley Ry., Vyara, Surat, India.
	1902 Mar. 11.	Pope, Arthur	Hatfield, The Grove, Slough.
	1903 Nov. 24.	Potts, Alfred Bertrand ..	Field View, Macclesfield.
	1901 Nov. 19.	Pratt, Francis Gerald ..	Bargate House, Mildenhall, Suffolk.
	1903 Mar. 31.	Preston, Frank Matthew ..	6 Albert Road, Saltaire.
	1902 Nov. 5.	Price, William James ..	Llanwern, Somerset Road, Boscombe, Bournemouth.
	1903 Dec. 22.	Purcell, Pierce Francis, B.A., B.A.I. (*Dublin*)	Chatham Row, Dublin.
	1902 Jan. 28.	Puri, Kashi Ram	Thos. Cook & Son, Ludgate Circus, E.C.
	1902 Mar. 25.	Purse, Frederick Walter ..	127 London Road, Stockton Heath, Warrington.

	Date of Admission.	STUDENTS.	
	1903 Dec. 15.	QUARTANO, ANDREW ..	16 Beech Grove Road, Newcastle-on-Tyne.
	1902 Mar. 25.	RAFFETY, SIDNEY ROBERT ..	Waterworks, 1 High Street, Gosport.
	1902 Dec. 23.	RAMPAL, LÉON MAXIME	Central Technical College, Exhibition Road, S.W.
	1903 Nov. 24.	RAPPIS, PIER ALESSANDRO GIORGIO, B.A. (*Cantab.*) ..	Marconi's Wireless Telegraph Co., Chelmsford.
	1904 Mar. 22.	RASHLEIGH, WILLIAM STUART, B.A. (*Cantab.*)	G. W. Ry., Engineer's Office, Paddington, W.
B m	1902 Jan. 28.	RATTENBURY, OSCAR BRANCH	Works Dept., Dockyard, Chatham.
	1903 Nov. 10.	RAVENHILL, DOUGLAS WALTER JULIUS	Victoria Lodge, Millbrook, Southampton.
	1899 Nov. 28.	REDMAN, ARTHUR STANLEY ..	Calne, Wiltshire.
	1899 Jan. 24.	RENDELL, ELIAS DE LA ROCHE	
	1900 Jan. 9.	RESTLER, JAMES DOUGLAS KENDALL	68 Linden Grove, Nunhead, S.E.
	1898 Nov. 8.	REYNOLDS, ALAN	H. H. Young, The Cottage, Old Normanton, Derby.
	1903 Nov. 24.	REYNOLDS, BERTIE	27 Woodville Road, Cardiff.
	1904 Mar. 29.	REYNOLDS, LEETHEM	Sandal, Wakefield.
	1900 Jan. 9.	RHODES, SAMUEL COLBY ..	Gordon College, Khartoum, Sudan.
	1901 Mar. 12.	RICHARDS, BERTRAM DARELL	Leigh View, Stoke Bishop, Bristol.
	1900 Nov. 27.	RICHARDS, NORMAN ESPLIN ..	Box 5124, Johannesburg, Transvaal.
	1899 Nov. 28.	RICHARDS, WILLIAM BRAILEY	Lower Ganges Canal, Kaimganj, India.
	1902 Feb. 4.	RICHARDSON, ALEXANDER ..	Marionville, Sciennes Gardens, Edinburgh.
	1903 Mar. 24.	RICHARDSON, CHARLES THOMAS	Boro' Engineer's Office, Dover.
	1903 Mar. 24.	RICHARDSON, FRANCIS AYMER	The Vicarage, Corbridge-on-Tyne.
	1903 Mar. 24.	RICHARDSON, JOHN STOCKS ..	Well Royd, Rawdon, Leeds.
	1903 Mar. 31.	RICHARDSON, WALTER MORRIS	Bod-Erw, St. Asaph, Flints.
	1903 Nov. 24.	RIDGWAY, LEOPOLD PENROSE	Newtown, Waterford.
	1904 Feb. 9.	RIDINGS, RALPH GRANT ..	31 Carson Road, West Dulwich, S.E.
	1904 Mar. 29.	RIGBY, WILLIAM JASON EDGELL	River Plate House, Finsbury Circus, E.C.
	1898 Feb. 22.	RISDON, PHILIP JAMES	Livesey, Son & Henderson, 14 South Place, E.C.
	1904 Mar. 29.	RITCHIE, HARRY CLEMENT ..	West View, Heaton Moor, Stockport.
	1903 Nov. 10.	ROBARTS, HERBERT PRIESTLEY	3 Warrender Park Terrace, Edinburgh.
	1902 Nov. 18.	ROBERT, ARTHUR WILLIAM ..	Closebrook, Simla, India.
	1901 Dec. 11.	ROBERTS, CYRIL HUMPHREY ..	Mrs. Forrest, 494 Great Western Road, Glasgow.
	1903 Mar. 24.	ROBERTS, EDWIN GILBERT LLEWELLYN	Park Lodge, Eltham, Kent.
	1903 Mar. 24.	ROBERTS, ERNEST DIGBY ..	16 The Leas, Folkestone.
	1902 Dec. 9.	ROBERTS, FRANK WILLIAM CRAMER	15 Onslow Gardens, S.W.
	1899 Feb. 7.	ROBERTS, JOHN EDWARD ..	Craven Place, Clee Hill, Ludlow.
	1904 Mar. 29.	ROBERTS, LEONARD	226 London Road, Croydon.
	1902 Nov. 5.	ROBERTS, WILLIAM DUNCAN LUND	2nd Circle, Irrigation, Cairo, Egypt.
	1900 Nov. 27.	ROBERTSON, WALTER HENRY ANTONIO	Elliott's Metal Co., Selly Oak Works, Birmingham.
	1902 Jan. 21.	ROBINSON, FRANCIS BERTRAM	Overdale, Skipton, Yorks.
	1904 Mar. 29.	ROBINSON, HUMPHREY INGRAM	King's College, Strand, W.C.
B m J	1900 Nov. 27.	ROBINSON, ISAAC VINCENT ..	Greenhow, Belle Vue, West Hartlepool.

Date of Admission.	STUDENTS.	
1903 Nov. 17.	Robinson, Reginald Braham	79 East Hill, Wandsworth, S.W.
1899 Nov. 28.	Robinson, William Percival	County Engineer's Office, Durham.
1903 Mar. 31.	Roche, Richard de Rupe ..	30 Mount Preston, Leeds.
1899 Mar. 28.	Rocher, Charles Guilliaume	Eastward Ry., Springs, Transvaal.
1902 Nov. 5.	Rodwell, Ernest Gravenor	Grindlay & Co., Bombay.
1903 Mar. 24.	Rootham, Howard Melville	12 Well Walk, Hampstead, N.W.
1900 Nov. 27.	Rosenheim, Ernest Albert, B.Sc. (*Victoria*)	1 Croxteth Road, Princes Park, Liverpool.
1900 Nov. 27.	Ross, Alfred Percy	c.o. A. Ross, 36 Fellows Road, South Hampstead, N.W.
1899 Nov. 28.	Rouse, Alexander Macdonald	44 Arundel Gardens, Notting Hill, W.
1903 Nov. 10.	Rowley, Harold George ..	"Sidmouth," Balham Park Rd., S.W.
1900 Nov. 27.	Rowley, John Reginald Phillips	Harbour Works, Pwllheli, N. Wales.
1902 Nov. 5.	Roy, Radhamadhao	P.O., Jalsuka, Sylhet, India.
1902 Mar. 25.	Royce, Bernard	West Leigh Road, Leicester.
1902 Mar. 25.	Royston, Christopher Clarke	Childwall Vicarage, Liverpool.
1903 Nov. 17.	Ruffhead, Alfred Ernest ..	19 Graham Rd., Wimbledon, S.W.
1903 Nov. 24.	Rusdell, William Joseph ..	South Staffs Mond Gas Co., Trendle House, Dudley.
1900 Mar. 27.	Russell, Robert	Derwent Valley Water Board, Bamford, Sheffield.
1904 Feb. 9.	Sabine, Harold William Townend Churchill ..	20 Chapter Road, Willesden Park, N.W.
1903 Nov. 10.	Salberg, Frank James	15 Northbrook Road, Lee, S.E.
1899 Mar. 28.	Salmon, Ernest Hinkly ..	8 Durham Road, Manor Park, E.
1902 Nov. 5.	Salt, Ernest Albert	Blithfield, New Malden, Surrey.
1901 Nov. 27.	Samy, Mahmoud	Nasrieh College, Cairo.
1901 Mar. 26.	Sandberg, Nils Percy Patrick	9 Bridge Street, Westminster, S.W.
1897 Nov. 10.	Sandberg, Oscar Fridolf Alexander	9 Bridge Street, Westminster, S.W.
1903 Nov. 10.	Sandeman, Charles Vaughan	The Chestnuts, Church, Accrington.
1904 Mar. 29.	Sanders, Carl Hubert ..	The Vicarage, Betchworth.
1901 Dec. 11.	Satow, Charles Francis ..	Northcote, Berkhamsted.
1904 Mar. 29.	Saxby, Herbert Baber ..	11 Gregory Street, Loughborough.
1902 Nov. 5.	Saxby - Thomas, Humbert George	98 New Walk, De Montfort Square, Leicester.
1901 Nov. 19.	Scard, Dudley Isenbart ..	76 Alexandra Street, Derby.
1899 Nov. 28.	Schoeberlein, Fritz	Genova, The Broadway, Sheerness.
1902 Mar. 25.	Schofield, Frank	74 Mossley Road, Ashton-under-Lyne.
1902 Mar. 25.	Scott, Hugh	44 Hova Villas, Hove.
1899 Feb. 14.	Seabrooke, Lawrence Mends	King, King & Co., Bombay.
1902 Nov. 11.	Segrave, James Henry ..	22 Lawford Road, Kentish Town, N.W.
1898 Nov. 22.	Serpell, Douglas Leslie ..	Derwent Valley Water Board, Bamford, Sheffield.
1901 Nov. 19.	Seth-Smith, Leslie, B.A. (*Cantab.*)	Alleyne, Caterham Valley, Surrey.
1904 Mar. 29.	Shakoor, Trevor Monsoor ..	7 Aubrey Road, Campden Hill, W.
1903 Nov. 10.	Sharpe, Charles Arthur, B.A. (*Cantab.*)	4 Broadlands Road, Highgate, N.
1897 Nov. 10.	Sharpley, Reginald	111 Iverna Court, Kensington, W.
1903 Jan. 13.	Shaw, Charles William ..	Park Villa, Dewsbury.
1903 Nov. 24.	Shaw, Francis Blewett ..	Southhill Rectory, Callington.
1903 Nov. 10.	Shaw, Thomas Alfred	26 Elms Avenue, Muswell Hill, N.
1899 Nov. 28.	Shelley, William John ..	Midland Ry., Engineer's Office, Derby.

Date of Admission.		STUDENTS.	
	1897 Apr. 6.	SHEPHERD, PERCY EDWARD ..	Engineer's Office, L. & Y. Ry., Hunt's Bank, Manchester.
	1900 Nov. 27.	SHEPLEY, JOHN THORPE	Picardy House, Belvedere, Kent.
	1903 Nov. 24.	SHEPPARD, CHARLES WESTCAR	211 Upper Richmond Road, Putney, S.W.
	1902 Dec. 2.	SHEPPARD, JAMES	Hawsted, Buckhurst Hill, Essex.
	1897 Nov. 10.	SHERREN, ARTHUR OSWALD ..	Boro' Engineer's Office, Dover.
	1903 Dec. 15.	SHILSTONE, WILLIAM CHARLES NELSON	Royal Indian Engineering College, Staines.
	1902 Nov. 5.	SHORTT, WILLIAM HAMILTON	Bramcote, Bramcote Road, Putney, S.W.
	1901 Jan. 15.	SIBETH, AUSTIN	Manor House, Sutton Park, Guildford.
	1903 Mar. 24.	SIDDALLS, WILLIAM FREDERICK	6 Ashmere Grove, Brixton, S.W.
	1902 Feb. 4.	SIDEBOTTOM, JOHN KERCHEVAL	Engineer's Office, L. & Y. Ry., Hunt's Bank, Manchester.
	1901 Dec. 17.	SILCOX, LEONARD ERNEST ..	H. B. Nichols, 11 Victoria St., S.W.
	1900 Nov. 27.	SIMEON, CHARLES JOHN	Statter & Co., Cornwall Buildings, Newhall Street, Birmingham.
	1898 Nov. 8.	SIMON, ERNEST DARWIN ..	20 Mount Street, Manchester.
	1903 Dec. 15.	SIMPSON, ALEC JAMES	8 Paultons Square, Chelsea, S.W.
	1898 Nov. 29.	SINCLAIR, ALFRED ROBERT ..	Mrs. Gow, 13 Rupert Street, Glasgow.
	1901 Nov. 27.	SINGH, BĀWĀ RAMNEEK ..	Agra-Delhi Chord Ry., Muttra, India.
	1903 Nov. 24.	SKELSEY, FREDERICK WALTER	The Hawthorns, Westbourne Avenue, Hull.
m	1897 Mar. 29.	SKINNER, CLIFTON MACLEAN ..	2 St. Paul's Terrace, Newcastle-on-Tyne.
	1902 Nov. 5.	SLEIGH, ALEXANDER IRVING ..	King, King & Co., Bombay.
	1902 Nov. 5.	SMALL, JAMES CAMERON ..	Ormonde, Mount Eden Road Donnybrook, Dublin.
	1898 Nov. 8.	SMITH, ALBERT BROMLEY ..	Sutcliffe Ventilating Co., Cathedral Corner, Manchester.
	1900 Nov. 27.	SMITH, CYRIL GRAHAM ..	
	1904 Mar. 29.	SMITH, FREDERICK GEORGE ..	Thames Ironworks, Tidal Basin, E.
	1903 Nov. 17.	SMITH, GEORGE MAKINS	6 Vanbrugh Park Road East, Blackheath, S.E.
	1903 Nov. 24.	SMITH, JOHN WOODHEAD ..	4 Belgrave Place, Bury.
	1897 Apr. 6.	SMITH, KENNETH BASIL WOODD	37 Charlton Road, Blackheath, S.E.
	1900 Nov. 27.	SMITH, LEONARD MOUNTFORD	Beesley, Son & Nichols, 11 Victoria Street, S.W.
	1901 Nov. 19.	SMITH, ROBERT MELVILLE ..	Wyndcliffe, Dudley.
	1902 Dec. 2.	SMITH, ULRIC VIVIAN	6 Tower Road, Dartford, Kent.
	1903 Feb. 3.	SMITH, VERNON CHARLES ..	8 Kingsford Street, Gospel Oak, N.W.
	1903 Mar. 24.	SMITH, WALTER JOHN	Town Hall, Staines.
	1901 Mar. 26.	SMITH, WILLIAM FREDERICK..	Upper Chenab Canal, Guyranwala, Punjab.
	1903 Mar. 24.	SMYTH, ARCHIBALD HUGH ..	Dunseverick, Barnet.
	1899 Nov. 28.	SNAPE, ALFRED ERNEST, B.Sc. (*Victoria*)	Engineer's Dept., London County Council, Spring Gardens, S.E.
	1903 Mar. 24.	SNEYD, GEORGE STUART ..	City & Guilds Institute, Exhibition Road, S. Kensington, S.W.
	1900 Nov. 27.	SOUTH, GEOFFREY WRENCH ..	17 Palace Road, Norwood, S.E.
	1904 Mar. 29.	SPALDING, PERCY ALFRED ..	14 Torrington Square, W.C.
	1898 Nov. 8.	SPARROW, CLAYTON STALLARD	132 Selhurst Road, S.E.
	1901 Nov. 27.	SPARTALI, MICHAEL	Gore Court, Otham, Maidstone.
	1900 Nov. 27.	SPEECHLY, EDWARD	51 Kingsmead Road, Tulse Hill, S.W.
	1903 Nov. 24.	SPEIGHT, HERBERT	121 Hawkshead Street, Southport.

Date of Admission.	STUDENTS.	
1898 Nov. 8.	SPENCER, EDMUND STONE, B.Sc. (*Victoria*)	Town Hall, Ilfracombe.
1902 Mar. 25.	SPENCER, EVELYN	Sandford Lodge, Southbourne, Christchurch, Hants.
1903 Nov. 24.	SPENCER, MAXIMILIAN HAROLD	93 Blenheim Crescent, Notting Hill, W.
1900 Dec. 18.	SPILSBURY, LIONEL BRUCE ..	Royal Indian Engineering College, Staines.
1902 Mar. 25.	SPOONER, ARTHUR DOUGLAS ..	33 Great George Street, S.W.
1898 Nov. 8.	STACEY, WILLIAM HENRY ..	Ingleside, Coleshill, Warwickshire.
1902 Nov. 5.	STALLARD, GEORGE WILLES ..	Horton Crescent, Rugby.
1903 Dec. 22.	STAMPE, WILLIAM LEONARD ..	Ash Lea, Grimsby.
1901 Nov. 27.	STANIER, CHARLES EDWARD, B.Sc. (*Lond.*)	Dorman, Long & Co., Middlesbrough.
1902 Nov. 11.	STEED, ALFRED WILLIAM ..	Royal College of Science, Exhibition Road, S.W.
1901 Mar. 26.	STEINBERG, HERBERT EDWARD	43 Parliament Hill, N.W.
1901 Nov. 27.	STEINTHAL, PAUL TELFORD ..	St. John's, Ilkley, Yorks.
1903 Nov. 24.	STERN, ALEXANDER CECIL ..	Royal Indian Engineering College, Staines.
1903 Feb. 17.	STEVENS, ARTHUR HAROLD ..	Redlands Rise, Alexandra Road, Reading.
1904 Mar. 29.	STEVENS, FRANCIS GEORGE ..	Town Hall Chambers, Torquay.
1902 Dec. 2.	STEVENS, HENRY JOHN HENLEY	Beechlawn, Parktown, Oxford.
1899 Mar. 28.	STEVENS, HERBERT LESLIE ..	2 Loates Lane, Watford.
1902 Nov. 11.	STEVENS, THOMAS HARRY GOLDSWORTHY	Compstall Hall, via Stockport.
1901 Nov. 19.	STEWART, BASIL	c.o. Mrs. Stewart, 52 Redcliffe Gardens, Kensington, S.W.
1903 Nov. 10.	STEWART, DONALD MACIVER	Dera Ghazi Khan, Punjab, India.
1903 Jan. 27.	STEWART, FREDERICK ROBERT, B.Sc. (*Glas.*)	Williamwood, Cathcart, Glasgow.
1903 Nov. 10.	STRACHAN, WILLIAM STEAD ..	51 Cavendish Road, Clapham Park, S.W.
1902 Dec. 2.	STREET, ARTHUR HUBERT ..	St. Margaret's, Berlin Road, Catford, S.E.
1901 Nov. 19.	STRINGER, HAROLD	2 Stokeville, Stoke-on-Trent.
1899 Nov. 28.	SVENSSON, GILLIS, B.Sc. (*Victoria*)	Albany Villa, College Road, Cheshunt.
1897 Nov. 10.	SWALES, JOHN KIRBY	City Engineer's Office, Leeds.
1901 Nov. 19.	SWAN, PERCIVAL	58 Holland Park, W.
1903 Nov. 24.	SWAYNE, HERBERT CHARLES ..	R. St. G. Moore, 17 Victoria St., S.W
1903 Dec. 15.	SYMES, WILLIAM FITZROY SCUDAMORE STALLARD ..	King's College, Strand, W.C.
1902 Dec. 2.	SZLUMPER, GILBERT SAVILE ..	L. & S.W. Ry., Engineer's Office, Clapham Junction, S.W.
1904 Feb. 9.	TABOR, ERIC MONTAGU	King's College, Strand, W.C.
1904 Mar. 29.	TANNOCK, JAMES FERGUSON ..	Woodend, Tarbolton, Ayrshire.
1903 Dec. 15.	TATE, THOMAS BAILEY	Royal Indian Engineering College, Staines.
1900 Nov. 27.	TAYLOR, JOHN HAROLD CLAYFIELD	G.N. Piccadilly & Brompton Ry., 6 Belgrave Street, King's Cross, N.
1904 Mar. 22.	TAYLOR, THOMAS HAROLD ..	3 Drayton Green Road, Ealing, W.
1902 Nov. 5.	TENNANT, NORMAN SCHOLEFIELD	Strathmore, Harrogate.
1903 Nov. 17.	TEULON, OLIVER HENRY ..	17 Kenilworth Avenue, Wimbledon, S.W.

Date of Admission.	STUDENTS.	
1903 Dec. 22.	THAIN, THOMAS EDWARD ..	11 Glendower Place, S.W.
1902 Jan. 28.	THATCHER, IVAN JAMES ..	124 Cromwell Road, Montpelier, Bristol.
1900 Nov. 27.	THISELTON-DYER, GEORGE HENRY, B.A. (*Cantab.*) ..	Waterworks, Commercial Road, Portsmouth.
1904 Mar. 15.	THOMAS, FRED, B.Sc. (*Victoria*)	Sutton Road, Somerton, Somerset.
m 1900 Mar. 27.	THOMAS, JOHN VICK	14 Alexander Road, Gloucester.
1903 Nov. 10.	THOMAS, MARTIN LEWIS ..	King's College, Strand, W.C.
1903 Jan. 13.	THOMAS, RICHARD EMRYS ..	Engineer's Office, L. & S.W. Ry., Waterloo, S.E.
1903 Nov. 24.	THOMAS, WILLIAM CLAUD ..	28 Mulgrave Street, Liverpool.
1904 Mar. 29.	THOMAS, WILLIAM LIONEL MAURICE	42 Gower Road, Forest Gate, E.
1903 Nov. 24.	THOMPSON, BERNARD VALENTINE	Borough Engineer's Office, Northampton.
1900 Mar. 27.	THOMPSON, EDWARD HORACE ..	Gwynne, Albemarle Road, Beckenham.
1902 Mar. 25.	THOMPSON, GEORGE NORMAN VERE	Ferndale, Richmond Road, Crewe.
1900 Nov. 27.	THOMPSON, MICHAEL STEPHEN	6 Clifton Villas, Wembley.
1901 Mar. 26.	THORNE, PHILIP HOWARD ..	Suspension Bridge, Conway, N. Wales.
1900 Mar. 6.	THORNHILL, WILLIAM JOHNSON	P.W.D., Colombo, Ceylon.
1897 Nov. 10.	THORNTON, ERNEST	The Poplars, Chidswell, Dewsbury.
1898 Dec. 20.	THORNTON, GILBERT MILLER ..	Govt. Rys., Uitenhage, Cape Colony.
1902 Dec. 2.	THORNTON, REGINALD CHRISTOPHER	Shire Hall, Nottingham.
1901 Nov. 27.	THORNYCROFT, ISAAC THOMAS	Eyot Villa, Chiswick Mall, W.
1903 Dec. 22.	THORP, HARVEY THOMAS ..	Moss Bank, Whitefield, Manchester.
1899 Nov. 28.	THORPE, WILLIAM ALFRED CHARLES	North Western Ry., Rawal Pindi, India.
1903 Nov. 17.	TIFFANY, FRANK, Jun.	8 Kelso Road, Leeds.
1901 Nov. 19	TODD, HERBERT	Indwe-Maclear Railway, Indwe, Cape Colony.
1903 Dec. 15.	TOPHAM, HARRY	Royal College of Science, S. Kensington, W.
1900 Nov. 27.	TOPLEY, JOHN WHITEMAN MORLAND	Humphreys & Glasgow, 38 Victoria Street, S.W.
1898 Nov. 8.	TOVEY, HENRY TURNER ..	39 Nevern Square, Earl's Court, S.W.
1901 Mar. 26.	TREDCROFT, ARTHUR FRANCIS	26 Rock Lane West, Rock Ferry.
1897 Mar. 29.	TREE, PHILIP BEAGLEY LE DESPENCER	Jhelum Canal, Sargodah, Shahpur District, Punjab.
1902 Mar. 25.	TREMLETT, PERCIVAL MERVYN	G.W. Ry., Engineer's Office, Bristol.
1898 Dec. 6.	TRESSLER, KARL THEODOR BERTHOLD, B.Sc. (*Lond.*) ..	P.W.D., Tanjore, Madras.
1904 Jan. 12	TREVOR-ROBERTS, ARTHUR, B.Sc. (*Victoria*)	7 Slatey Road, Claughton, Birkenhead.
1903 Jan. 20.	TREWBY, ARTHUR, B.A. (*Cantab.*)	G. C. Trewby, Fenton House, Hampstead Heath, N.W.
1899 Nov. 28.	TRIER, FRANK NEWTON	6 The Terrace, Champion Hill, S.E.
1903 Apr. 7.	TRIMMER, GEORGE WILLIAM ARTHUR	Broadgate Villa, Grasmere, Westmoreland.
1902 Feb. 4.	TRIPP, GEORGE WALTER	13 Grafton Road, Bedford.
1904 Mar. 29.	TRIPP, WILLIAM HOWARD SANDBERG	W. T. Douglass, 15 Victoria Street, S.W.
1904 Apr. 12.	TROUGHTON, HENRY JAMES ..	L.C.C. Tramways, 303 Camberwell New Road, S.E.
1900 Nov. 27.	TUDOR, FREDERIC EDWARD ..	District Engineer's Office, N. E. Ry., York.
1904 Apr. 12.	TUDSBERY, HENRY TUDSBERY	125 Thurlow Park Road, Dulwich, S.E.
1903 Nov. 10.	TURNBULL, WALTER ALEXANDER	43 Chesham Road, Bury.

Date of Admission.	STUDENTS.	
1904 Mar. 29.	Turner, Arthur Mitchell	5 Goldswong Terrace, Nottingham
1900 Nov. 27.	Turner, Elwyn Meyrick ..	3 Windermere Road, Muswell Hill, [N.
1902 Dec. 2.	Turner, Fred	34 Wesley Street, Morley.
1898 Nov. 8.	Turner, Sydney George ..	23 Earl's Court Gardens, S.W.
1903 Apr. 21.	Turrall, Richard Henry ..	Torrington, N. Devon.
1904 Mar. 29.	Tutt, Ernest Leo Healey ..	A. T. Walmisley, 9 Victoria Street, S.W.
1902 Nov. 5.	Tyack, Edgar James	Rutland Hotel, Bakewell.
1900 Nov. 27.	Tyrrell, George Nugent Merle	9 Hall Street, Chelmsford.
1903 Nov. 24.	Udale, Stanley Martin ..	33 The Avenue, Bedford Park, W.
1898 Jan. 25.	Unwin, Howard Buckley ..	1 Newton Grove, Bedford Park, W.
1900 Mar. 27.	Upton, Mitchell Henry ..	
1903 Nov. 24.	Ure, Robert	46 Maxwell Drive, Glasgow.
1904 Mar. 22.	Urquhart, George	6 Derby Street, Mayfair, W.
1903 Nov. 10.	Uttley, James Arthur, B.Sc. (*Victoria*)	Manor Heath, Napier Road, Heaton Moor, Manchester.
1904 Mar. 29.	Vale, Percy Thomas	King's College, Strand, W.C.
1903 Mar. 24.	Valon, William Argentine McIntosh	503 Pitsmoor Road, Sheffield.
1904 Feb. 9.	Van der Meersch, André Emmanuel Marie Frédéric	Central Technical College, Exhibition Road, S.W.
1902 Nov. 5.	Varvill, Michael Noel ..	Woodcote, Redington Road, Hampstead, N.W.
1898 Nov. 22.	Venables, Arthur Vincent	East Indian Ry., Howrah, Bengal.
1902 Dec. 2.	Vogel, Heinrich Ernst Theodor	10 Mount Adon Park, Dulwich, S.E.
1903 Nov. 17.	Vogel, Roger Ferdinand ..	12 Manor Court Road, Hanwell, W.
1902 Dec. 2.	Wainwright, Hubert Cyril Thomas	Boro' Engineer's Office, Wolverhampton.
1904 Mar. 29.	Waite, George Arthur ..	22 Burnett Avenue, Bradford.
1901 Mar. 26.	Wales, William Arthur ..	Corporation Electricity Works, Ashton-under-Lyne.
1903 Dec. 22.	Walker, Edward George ..	39 Cale Street, Chelsea, S.W.
1902 Nov. 5.	Walker, Frank Egerton ..	Central Technical College, Exhibition Road, S.W.
1900 Mar. 27.	Walker, George	Firs Brake, Leckhampton, Cheltenham.
1903 Dec. 22.	Walker, Gilbert, B.A. (*Oxon.*)	36 Oakley Crescent, Chelsea, S.W.
1900 Dec. 18.	Walker, John Clive	41 Hamilton Terrace, St. John's Wood, N.W.
1900 Apr. 3.	Walker, Thomas Archibald, B.A. (*Cantab.*)	56 Claverton Street, Pimlico, S.W.
1897 Nov. 23.	Walkey, Oliver Rowland	Canopus, Rothsay Gardens, Bedford.
1904 Jan. 12.	Wallace, Thomas Waller ..	24 Fopstone Road, Earl's Court, S.W.
1900 Mar. 27.	Walmsley, Harold	Arncliffe, Whitegate Drive, Blackpool.
1902 Mar. 25.	Walton, Arthur Moore ..	12 Little College Street, Westminster, S.W.
1899 Jan. 10.	Walton, Eustace Ball ..	J. E. Walton, 4 Norfolk Villas, Musgrave Road, Durban, Natal.
1899 Mar. 28.	Walton, John Sewell	Town Hall Chambers, Torquay.

Date of Admission.	STUDENTS.	
1900 Nov. 27.	WARD, EBENEZER THOMAS ..	Rissington, Hadleigh Road, Leigh-on-Sea.
1902 Nov. 5.	WARD, HENRY PILKINGTON, B.Sc. (*Victoria*)	Ambleside, Withington Road, Whalley Range, Manchester.
1903 Dec. 22.	WARMINGTON, EDWARD STEPHEN, B.A. (*Cantab.*) ..	7 New Square, Lincoln's Inn, W. C.
1899 Nov. 28.	WARWICK, HUGH BRANSTON	King, King & Co., Bombay.
1897 Jan. 12.	WATERHOUSE, GILBERT	Greenfields, Rhayader, Rads.
1901 Dec. 3.	WATERMEYER, THEODORE HEINRICH	Jonkers Hoek, Stellenbosch, Cape Colony.
1903 Nov. 24.	WATERS, HORACE FRANK ..	30 Arthur Road, Brixton, S.W.
1904 Mar. 29.	WATKINS, ARTHUR ALBERT ..	34 Haymarket Terrace, Edinburgh.
1901 Nov. 19.	WATNEY, WILLIAM HERBERT, B.A. (*Cantab.*)	Thames Ironworks, Blackwall, E.
1903 Nov. 10.	WATSON, HERBERT, B.E. (*Royal*)	38 Eglantine Avenue, Belfast.
1901 Dec. 3.	WATSON, HUGH SEXTUS ..	10 Essendine Road Maida Hill, W.
1901 Nov. 19.	WATTS, SIDNEY JOHNSON ..	Trinity Hall, Cambridge.
1899 Nov. 28.	WATTS, STAFFORD TRACEY ..	Box 179, Barberton, Transvaal.
1903 Nov. 10.	WEBB, LEONARD ALEC VERNON	39 Kensington Gardens Square, W.
1903 Mar. 24.	WEEKS, EDMUND GEORGE ..	29 Lansdowne Grove, Neasden, N.W.
1900 Nov. 27.	WELCH, RICHARD HUBBARD ..	Royal Survey Dept., Bangkok, Siam.
1903 Dec. 22.	WELLER, HENRY OWEN, B.Sc. (*Glasgow*)	32 St. John's Road, Watford, Herts.
1899 Dec. 5.	WELLER, WALTER KIRKWOOD	P.W.D., Coolgardie Water Scheme Branch, Perth, Western Australia.
1903 Nov. 24.	WELLS, WILLIAM	East View, Horden Colliery, Easington, Co. Durham.
1901 Mar. 5.	WESSEL, HARRY LUIS	Beéche, Duval & Co., 25 Broad St., New York, U.S.
1901 Dec. 17.	WETHERALL, ARTHUR	67 Second Avenue, Heaton, Newcastle-on-Tyne.
1899 Nov. 28.	WHEATCROFT, KENNETH DOUGLAS	Waltham House, Wirksworth.
1903 Nov. 17.	WHEATON, HAROLD JOSEPH ..	Central Technical College, S. Kensington, S.W.
1902 Nov. 25.	WHEELER, WILLIAM THOMAS	4 Grove Road, Barnes, S.W.
1897 Nov. 23.	WHIGHAM, GEORGE HAY ..	160 Hope Street, Glasgow.
1903 Nov. 17.	WHILE, AUGUSTUS	Central Technical College, S. Kensington, S.W.
1899 Nov. 28.	WHITE, COLIN ROBERT.. ..	Admiralty Harbour Works, Dover.
1897 Nov. 10.	WHITE, ERNEST CLARK, B.Sc. (*Victoria*)	63 Daisy Hill, Dewsbury.
1902 Nov. 5.	WHITE, FRANCIS MARIE JOSEPH	Ardenham, Somerset Rd., Ealing, W.
1902 Dec. 2.	WHITE, WALTER	49 North Place, Guildford.
1902 Apr. 22.	WHITEHEAD, ALAN OCTAVIUS	Deighton Grove, York.
1903 Mar. 24.	WHITLEY, FRANCIS GRENVILLE	Manor Office, Eastbourne.
1901 Apr. 16.	WHITLEY, ROGER, B.A. (*Cantab.*)	44 Frognal, Hampstead, N.W.
1903 Mar. 24.	WHITSON, RALPH ALEXANDER	7 Windsor Quadrant, Glasgow.
1900 Mar. 27.	WHITTINGTON-COOPER, ALFRED	26 Kenilworth Court, Putney Bridge, S.W.
1901 Nov. 19.	WHITTLE, BERTRAM ARTHUR	59 Earlsfield Road, Wandsworth, S.W.
1903 Mar. 24.	WICKENDEN, ERNEST	16 Claremont Rd., Tunbridge Wells.
1899 Dec. 5.	WICKHAM, JOHN AVENEL ..	Hill House, Tetbury, Glos.
1903 Dec. 15.	WILDER, HARRY HILLIARD ..	48 Cambridge Gardens, North Kensington.
1897 Nov. 10.	WILKES, JOSEPH ERNEST ..	The Sycamores, Pelsall, Walsall.
1899 Nov. 28.	WILKINSON, NEWMAN	Boro' Engineer's Office, Batley.
1903 Nov. 17.	WILL, ROBERT WILLIAM, Jun.	42 Colinton Road, Edinburgh.
1900 Nov. 27.	WILLIAMS, ALFRED GLYN ..	11 Weld Road, Birkdale, Southport.
1903 Jan. 20.	WILLIAMS, HAROLD CRAIGIE, B.A. (*Oxon.*)..	4 Derwent Square, Stoneycroft, Liverpool.

Date of Admission.	STUDENTS.	
1899 Mar. 28.	WILLIAMS, JAMES STANLEY ..	Boro' Engineer's Office, West Ham.
1899 Mar. 28.	WILLIAMSON, ANDREW	Derwent Valley Water Board, Bamford, Sheffield.
1903 Mar. 24.	WILLIAMSON, HUGH PASS ..	Oak Avenue, Romiley, Stockport.
B 1902 Nov. 5.	WILLIAMSON, JAMES	Westfield Farm, Holytown.
1904 Mar. 29.	WILLCOX, BENJAMIN BRUCE ..	34 Hamilton Terrace, St. Johns Wood, N.W.
1899 Mar. 28.	WILLSON, CYRIL FREDERICK ..	The Old Rectory House, Wimbledon Park.
1903 Jan. 13.	WILSON, CYRIL SPENCER ..	Woodville, Lansdown, Bath.
1904 Mar. 29.	WILSON, ERNEST	52 Allen Road, Wolverhampton.
1896 Nov. 16.	WILSON, HARRY BERTRAM ..	Fairview House, St. Margaret's, Twickenham.
1904 Jan. 12.	WILSON, HERBERT CLARKE ..	Willow House, Penistone.
1900 Mar. 27.	WILSON, JOSEPH DOUGLAS ..	Engineering School, Crystal Palace, S.E.
1901 Mar. 26.	WILSON, JOSEPH LUPTON ..	11 Gregory Street, Loughborough.
1900 Nov. 27.	WIMBUSH, HENRY LAWRENCE	380 Liverpool Road, Patricroft, Manchester.
1901 Feb. 12.	WINGFIELD, GODFREY LEE ..	3 Leamington Villas, Chiswick Lane, W.
1898 Nov. 8.	WINTER, ERNEST CHARLES ..	Ivydene, Hathersage, Sheffield.
1900 Mar. 27.	WISE, JAMES BERKELEY	Cork, Bandon & S.C. Ry., Bandon.
1903 Nov. 17.	WOLFF, MARTIN	Ashurst, Sydenham, S.E.
1899 Mar. 28.	WOLSTENHOLME, FREDERIC GEORGE	4 Hornby Road East, Blackpool.
1902 Jan. 21.	WOOD, ALPHONSE, Jun... ..	Osborne House, Barnsley.
1901 Dec. 17.	WOOD, FRANCIS HUGO LINDLEY	88 Eaton Square, S.W.
1902 Dec. 2.	WOOD, HENRY	City Engineer's Office, Norwich.
1903 Mar. 24.	WOOD, RICHARD	The Neuk, Middlewich.
1901 Mar. 26.	WOOD, WILLIAM WELLESLEY	54 Lovaine Place, Newcastle-on-Tyne.
1900 Nov. 27.	WOODWARD, EDWARD	E.I. Ry., Buxar, India.
1902 Feb. 11.	WOOLDRIDGE, EDWARD PERCY	Contractor's Office, Somerton, Somerset.
1900 Nov. 27.	WRAGG, HERBERT	14 Beaumont Terrace, Spennymoor, co. Durham.
1903 Nov. 17.	WRIGHT, ALBERT FREDERICK JAMES	56 Prince Edward Road, Victoria Park, N.E.
1904 Mar. 29.	WRIGHT, ARTHUR REGINALD ..	3 Eastbourne Terrace, West Hartlepool.
1899 Jan. 31.	WRIGHT, ERNEST WILLIAM BELL	York Villa, Stanwise, Carlisle.
1900 Mar. 27.	WRIGHT, FRANK WILSON ..	Ivanhoe, Foley Park, Kidderminster.
1903 Nov. 24.	YARROW, HAROLD EDGAR ..	Woodlands, Blackheath, S.E.
1901 Dec. 17.	YOUNG, CYRIL ROE MUSTON ..	c/o W. T. Douglass, 15 Victoria Street, S.W.
1901 Nov. 19.	YOUNG, GEORGE SHIEL ..	Niven and Haddin, 131 West Regent Street, Glasgow.
1904 Jan. 26.	YOUNG, JOHN STEVENSON, B.Sc. (*Victoria*)	Kirby Park, West Kirby, Cheshire.
1904 Jan. 26.	YOUNG, THOMAS ADAIR	19 Cluny Drive, Edinburgh.

Total number of Students .. .. 1,075.

LONDON: PRINTED BY WILLIAM CLOWES AND SONS, LIMITED, DUKE STREET, STAMFORD STREET, S.E., AND GREAT WINDMILL STREET, W.